CSIRO
Division of Food Research
Institute of Animal and Food Sciences

Report of Research 1984–85

DIVISION OF FOOD RESEARCH

Headquarters of Division and Food Research Laboratory (FRL)

Delhi Road, North Ryde, NSW.
Postal address: PO Box 52, North Ryde, NSW 2113.
Telephone: (02) 887 8333; Telex 23407

Officers also located at

Plant Physiology Group,
School of Biological Sciences,
Macquarie University, North Ryde, NSW 2113.
Telephone: (02) 88 9471

Tasmanian Food Research Unit,
CSIRO Tasmanian Regional Laboratory,
'Stowell', Stowell Avenue, Hobart, Tas. 7000.
Telephone: (002) 23 5555; Telex 58300

CSIRO Darwin Laboratories,
McMillans Road, Berrimah, NT.
Postal address: Private Bag No.44, Winnellie, NT 5789.
Telephone: (089) 84 3611; Telex 85294

Dairy Research Laboratory (DRL)

Graham Road, Highett, Vic.
Postal address: PO Box 20, Highett, Vic. 3190.
Telephone: (03) 555 0333; Telex 33766

Officers also located at

The Russell Grimwade School of Biochemistry,
University of Melbourne, Parkville, Vic. 3052.
Telephone: (03) 341 5915

Meat Research Laboratory (MRL)

Corner Creek and Wynnum Roads, Cannon Hill, Qld.
Postal address: PO Box 12, Cannon Hill, Qld 4170.
Telephone: (07) 399 3122; Telex 40150

Officers also located at

WA Department of Agriculture,
Jarrah Road, South Perth, WA 6151.
Telephone: (09) 367 7261; Telex 93304

CSIRO Division of Animal Health,
Corner Flemington Road and Park Drive, Parkville, Vic.
Postal address: Private Bag No.1, Parkville, Vic. 3052.
Telephone: (03) 347 2311, 347 2632; Telex 32677

Hawkesbury Agricultural College,
Richmond, NSW 2753.
Telephone: (045) 78 2231

Industry and Consumer Liaison Officers, to whom inquiries may be directed, are listed on page 118 of this Report.

Laboratory operated jointly by CSIRO and NSW Department of Agriculture

Gosford Horticultural Postharvest Laboratory,
Pacific Highway, West Gosford, NSW.
Postal address: PO Box 355, Gosford, NSW 2250.
Telephone: (043) 24 3844

Front cover: A selection of appetizers

Commonwealth Scientific and Industrial Research Organization
Australia

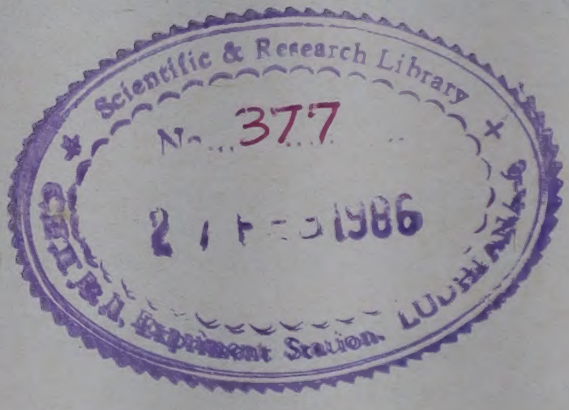
DIVISION
OF
FOOD RESEARCH

A Division of the Institute of Animal and Food Sciences

Report of Research

1984/85

Sydney



Printed by CSIRO, Melbourne

When the Council for Scientific and Industrial Research, which was to become CSIRO, was established in 1926, one of the first areas of investigation was the preservation and transport of food. In 1932, CSIR formed a Section of Food Preservation and Transport to work on problems in the storage and distribution of meat and fresh fruit. The success of this work laid secure foundations for developing export industries based on these and other primary products.

In 1938 the Section's headquarters was moved from Brisbane, Queensland, to Homebush, New South Wales. At the same time the scope of its research in food science and technology was broadened: studies on fish and eggs were begun, while meat research continued at the Brisbane Laboratory. During the Second World War, research was concentrated on problems of canning and drying foodstuffs. In 1941 the Section became the Division of Food Preservation and Transport. Twenty years later, the Division moved into new headquarters at North Ryde, New South Wales.

Meanwhile, a separate but parallel development was taking place in dairy research. In 1929 CSIR awarded an overseas studentship for research in dairying and dairy manufacture. A Dairy Research Section was formed during the Second World War, and this became the Division of Dairy Research in 1962. Early successes included advances in the mechanization of cheese manufacture.

In 1971, the Divisions of Dairy Research and Food Preservation were amalgamated to form the Division of Food Research, with three main laboratories.

The Food Research Laboratory (FRL) at North Ryde, New South Wales, erected in 1961, has laboratories for chemistry, biochemistry, physics, microbiology, plant physiology and food technology, a series of controlled temperature rooms, a food processing and packaging pilot plant, and facilities for plant growth in controlled environments. Part of the Plant Physiology Group is maintained in the School of Biological Sciences at Macquarie University. The Headquarters of the Division is located in FRL.

The Meat Research Laboratory (MRL) at Cannon Hill, Queensland, erected in 1967 (Stage I) and 1969 (Stage II), has laboratories for chemistry, biochemistry, physics, microbiology, animal physiology and electron microscopy, a series of controlled temperature rooms, a meat processing pilot plant, and animal handling and slaughtering facilities.

The Dairy Research Laboratory (DRL) at Highett, Victoria, erected in 1955 and extended 1970, has laboratories for chemistry, biochemistry and microbiology, and a comprehensive pilot plant for processing milk products.

In addition, the Division maintains a Food Research Unit concerned mainly with seafoods at the CSIRO Tasmanian Regional Laboratory, Hobart, and operates, in conjunction with the New South Wales Department of Agriculture, the Gosford Horticultural Postharvest Laboratory. A Postharvest Laboratory is also maintained at the CSIRO Darwin Laboratories, Northern Territory.

Contents

FOOD RESEARCH 1984–85

General review

Introduction

In March 1985 the Division of Food Research experienced its first external review in 19 years. The Review Committee consisted of Dr K.A.Ferguson (Director, CSIRO Institute of Animal and Food Sciences) as Chairman, Dr A.J.Bailey [Director, AFRC Food Research Institute - Bristol (formerly ARC Meat Research Institute), Langford, UK], Mr E.W.Barr [formerly Area Director (Pacific), H.J.Heinz & Co.(USA)], Mr P.E.Seale (Chief Chemist, Golden Circle Cannery, Brisbane, Qld), Dr A.Skulberg (Director, Norwegian Food Research Institute) and Professor B.A.Stone (La Trobe University, Melbourne, Vic.). Mr A.W.Charles (Secretary, CSIRO Institute of Animal and Food Sciences) served as secretary to the Committee.

Divisional Review Committee meeting at FRL in March 1985

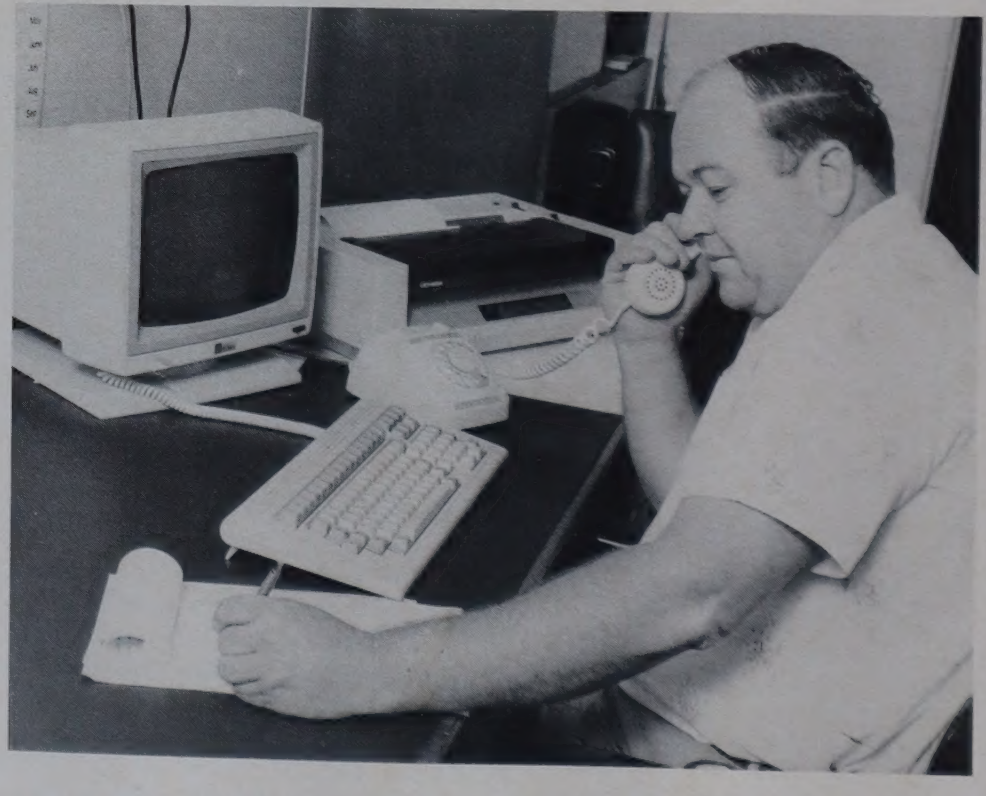
The Committee met first at the Food Research Laboratory, North Ryde, for five days which included a visit to members of the Division's Plant Physiology Group located at Macquarie University. Two days were spent at both the Meat Research Laboratory, Cannon Hill, Qld and the Dairy Research Laboratory, Highett, Vic., with a final one-day discussion at the CSIRO Regional Administrative Office. Melbourne. The members inspected research facilities and heard reports of scientific research and of technology transfer activities. They considered more than 80 written submissions, including a major document from the Chief of the Division, and received a number of personal submissions.

The Review was a stimulating experience for the Division's staff with the Committee showing great interest in and perception of our work. The Division is most grateful to the Committee members for the time and effort that they put into the Review. It is hoped that their Report will be considered by the CSIRO Executive before the end of 1985.

The Divisional Review was followed closely by the ASTEC Review of Public Investment in Research and Development in Australia which concentrated initially on CSIRO's top management structure and on Divisions' involvement with industry. The Division's three Laboratories were visited by various members of the ASTEC Working Group, and the Chief and Assistant Chiefs attended discussions with Working Group members at central locations in three cities.

Commercialization of the Division's inventions accelerated during the year. This process was aided in a number of instances by the recently-formed SIROTECH Limited. However, the Division's Appropriation funding continued to decline in real terms, and it was necessary to leave vacant a further 12 positions that fell vacant during the year. Increased support from industry funds enabled the Division's overall research activities to be maintained at about the same level as in 1983/84.

The number and nature of inquiries answered by staff of the Division has been assessed. Of a total of 10 000 inquiries received per year, some 60 per cent are from the food and related industries, with nearly one-half coming from companies with more than 100 employees. Government departments and consumers each account for 12 per cent, with the remainder from educational institutions, students and the media.



Answering inquiries using the new database

On 1 December 1984 an Energy Management Unit was established by CSIRO within the Buildings and Property Section of the Finance and Administration Branch of the Organization. The Unit comprises three officers who have been seconded from the Division of Food Research and is located at the Division's Meat Research Laboratory, Cannon Hill, Qld.

Finance

The Division is funded mainly from Appropriation sources, but a significant proportion of the research is funded by Commonwealth and State departments, statutory bodies, and the food industry.

Expenditure by Source of Funds	$
Appropriation Funds: Annual (including Employer Superannuation Contributions $1 293 009)	10 017 579
Capital	352 125
Repairs and Maintenance	414 669
Contributory Funds	
MRL	
Australian Meat Research Committee	
Research Projects	622 867
Industry Section	691 570
Pig Industry Research Committee	7 352
DRL	
Australian Dairy Research Committee	233 906
APV-Bell Bryant Pty Ltd, APV International Ltd and Milk Marketing Board of England and Wales	293 433
Asia Dairy Industry Research Agreement	34 998
Dairy Industry Marketing Authority of New South Wales	31 915
Department of Industry, Commerce and Technology (Productivity Grant)	72 872
Miles Laboratories Aust.Ltd	37 684
Oilseeds Research Committee	31 157
Schreiber Foods Inc.	102 433
FRL	
Australian Centre for International Agricultural Research	406 598
Australian Development Assistance Bureau	45 821
Department of Primary Industry	45 293
Dried Fruits Research Committee	77 139
Fishing Industry Research Committee	156 227
National Peanut Council of Australia	10 199
NSW Department of Agriculture	71 333
Rural Credits Development Fund	27 339
Miscellaneous Contributions (including General Donations)	72 137
Total Funds 1984-85	$13 856 646

Staff

Composition and location of staff, including apprentices and staff employed for limited periods on development projects, casual labour and special Government-sponsored training programs, at 30 June 1985 was as follows:

	Professional Staff	Other Staff	Total
Headquarters			
North Ryde	2	1	3
FRL			
North Ryde	74	69	143
Macquarie University	6	3	9
Gosford	-	2	2
Mildura	1	-	1
Hobart	6	4	10
MRL			
Cannon Hill	33	46	79
Melbourne	1	1	2
Perth	1	1	2
Sydney	1	1	2
DRL			
Highett	29	40	69
University of Melbourne	1	1	2
Total	155	169	324

Appointments

The following appointments were made to the Division:

DRL

Mr G.Dixon, Experimental Scientist - to work on project to develop High-Yield Cheese Process.

Messrs G.S.Barnes and G.J.Randall, Administrative Officers.

FRL

Miss A.M.Irwin, Experimental Scientist - to study mould growth in peanuts after harvest (CSRG and National Peanut Council Grant).

Mr Nhi Chau-Ngoc, Experimental Scientist - to work on counter-current extraction project.

Mr P.A.Constable, Administrative Officer.

MRL

Miss D.E.Miller, Post-Graduate Student (CSIRO Division of Food Research and Griffith University) - to study storage life of vacuum-packed chilled pork (funded by Australian Pig Industry Research Committee).

Cessations

The following ceased duty with the Division:

DRL

Mr H.J.van Leeuwen, Experimental Scientist, Cheese Technology Group.

Messrs J.Ryan, D.J.McCullough and G.J.Randall, Administrative Officers.
Mr W.P.Rogers, Senior Technical Officer, retired in January 1985 after 29 years' service.

FRL

Mr E.G.Davis, Principal Research Scientist, retired in July 1984 after 34 years' service; Mrs P.M.Moy, Technical Officer, in July 1984 (33 years' service); Miss D.E.Fenwick, Experimental Scientist, in August 1984 (26 years' service); Mr A.J.Boss, Technical Officer, in January 1985 (22 years' service); Dr W.G.Murrell, Chief Research Scientist, in February 1985 (36 years' service); Mrs B.J.Stewart, Experimental Scientist, in February 1985 (40 years' service); Dr D.L.Ingles, Principal Research Scientist, in March 1985 (29 years' service).
Miss H.J.P.Smith, Experimental Scientist - fresh tomato quality improvement project.

Secondments

The initial 2-year secondment of Mr S.J.Thrower, Experimental Scientist, Tasmanian Food Research Unit (TFRU), to the Tasmanian Fisheries Development Authority was extended by six months to 30 November 1984 at the request of the Authority.

Messrs J.W.Buhot, Experimental Scientist, J.Anderson and W.K.Larnach, Senior Technical Officers (MRL) were seconded to the newly-established CSIRO Energy Management Unit for three years from 1 December 1984.

Honours and awards

To honour Dr J.R.Vickery, Foundation Chief of the Division, the Australian National Committee of the International Institute of Refrigeration created the James R.Vickery Award, an annual award for outstanding achievements in the application of refrigeration to the preservation of foods and food products.

Mr J.F.Kefford, Honorary Research Fellow, was elected a Fellow of the Australian Academy of Technological Sciences.

The Best Paper Award was won by Mr K.Visser (Managing Director, K.Visser & Associates) and Mr L.S.Herbert, Principal Research Scientist (MRL) for their joint paper entitled 'Progress report on the development of a large scale automatic plate freezer for cartons of meat' published in the March 1983 edition of the Journal of the Australian Institute of Refrigeration, Airconditioning and Heating (AIRAH).

Mr B.F.Le Breton, who completed his Apprenticeship (Carpenter) at FRL in 1983, was awarded the 1983 Arthur Frost Memorial Award, which is judged on overall merit and improvement in the full term of Apprenticeship.

Miss F.Separovic (FRL) was elected the student representative to the Academic Senate of Macquarie University.

Dr R.W.Sleigh (FRL) was awarded a CSIRO Overseas Fellowship for 1984/85 to study protein separation.

Messrs F.G.Kieseker, P.T.Clarke and B.Aitken (DRL) received the Australian Journal of Dairy Technology Award for their publication on recombination and reconstitution processes for the preparation of dairy products.

Mr L.L.Muller, Officer-in-Charge, DRL, was elected Federal President of the Australian Society of Dairy Technology.

At the Annual General Meeting of the Australian Institute of Food Science and Technology in June 1985, Mr F.J.van Doore (MRL) presented a paper 'The development of a dynamic equilibration cell for the determination of food product adsorption/desorption isotherms' for which he received the Malcolm Bird Commemorative Award for AIFST Young Members.

Dr A.F.Egan (MRL) was appointed Honorary Senior Fellow of the School of Science, Griffith University, Nathan, Qld.

Degrees were conferred on the following staff:

Mr M.A.Brown - PhD (Macquarie University)
Mr G.R.Chaplin - PhD (University of New South Wales)
Mr H.R.Kocak - MSc (Royal Melbourne Institute of Technology)
Mr H.H.N.Panhuber - MSc (Macquarie University)
Mr M.Free - BSc (Caulfield Institute of Technology)
Miss G.Orr and Mr P.Watt - BSc (Macquarie University)
Miss D.J.Devine and Mr F.J.van Doore - BAppSci (Queensland Institute of Technology).

Guest workers

The Division's Laboratories were visited by many research workers from institutions and universities both in Australia and overseas. The following spent three weeks or more at one of the Laboratories:

At DRL:

Dr M.K.Salooja, College of Dairy Science, Udaipur, India - training in dairy field, with special emphasis on concentrated and dried milk technology (Commonwealth Scholarship Fellowship Plan - ADAB Training Aid: India).

Dr G.P.McCabe, Department of Statistics, Purdue University, and Mrs McCabe, Consultant, West Lafayette, Indiana, USA - joint studies with CSIRO Divisions of Mathematics and Statistics, and Food Research.

Associate Professor M.E.Mangino, Department of Food Science and Nutrition, Ohio State University, Columbus, Ohio, USA - collaborative studies on the functionality of dairy protein concentrates.

At FRL:

Dr R.L.Gunther, Hobart, Tasmania - studies of carbonic acid-buffer systems (at TFRU, Hobart).

Associate Professor A.G.Huddar, UNDP/FAO/ICAR Centre of Advanced Studies in Tropical Horticulture, University of Agricultural Sciences, GKVK, Bangalore, India - collaborative research on postharvest physiology and technology of fruit and vegetable storage (FAO Fellowship).

Dr S.Koike, Hokkaido National Agricultural Experiment Station, Sapporo, Japan - studies on glutathione in relation to chilling injury (Japanese Government Grant - Ministry of Education).

Messrs P.Castan and B.Delaval, Ecole Nationale Superieure de Biologie Appliqué à la Nutrition et à l'Alimentation (ENS.BANA), Université de Dijon, France - research training in food technology and food engineering.

Dr H.R.Bolin, USDA Western Regional Research Center, Berkeley, California, USA - collaborative studies on dried foods.

Professor J-P.Simon, University of Montreal, Canada - collaborative studies on isolation of PEP carboxylases.

Miss C.J.Potvin, Duke University, North Carolina, USA - studies on methods to measure chilling sensitivity.

Dr T.Matsuo, Kagoshima University, Japan, and Mrs Takako Matsuo, Japan - collaborative research on cold sensitivity of proteins in plants in relation to chilling in horticultural produce.

Mr Chen Yi-Zhu, South China Institute of Botany, Academia Sinica, Kwangchow, People's Republic of China - collaborative work on chilling injury in plants.

Associate Professor P.W.Westerman, College of Medicine, Northeastern Ohio Universities, Rootstown, Ohio, USA - synthesis of labelled phospholipids and ubiquinone compounds and n.m.r. studies of their interaction.

Dr R.Smith, University of Queensland - synthesis of labelled polypeptides and study of their interaction with model membranes.

Dr P.J.Quinn, Chelsea College, University of London, UK - continuing collaboration on study of the function of quinones in transport systems.

Miss A.Post, Macquarie University, Sydney, NSW - study of ubiquinone and plastiquinone within membranes.

Dr M.Keniry, University of California, USA - studies of interaction of labelled ubiquinone with model membranes.

Professor Sir Rutherford N.Robertson, University of Sydney, NSW - study of the interaction of ubiquinone with model and biological membranes.

Associate Professor P.L.Yeagle and Dr A.Albert, State University of New York, USA - collaborative n.m.r. studies on protein-lipid interactions.

Professor R.Aloia, Department of Anesthesiology and Biochemistry, Loma Linda University, California, USA - collaborative research on physiological implications of alterations in membrane lipid composition and fluidity.

Dr D.V.Vadehra, Director, Regional Sophisticated Instrumentation Centre and Central Instrumentation Laboratory, Panjab University, Chandigarh, India - continued collaborative research on egg protein and related studies.

Mr G.C.Fletcher, Division of Horticulture and Processing, DSIR, Auckland, New Zealand - microbiological spoilage of seafoods (at TFRU, Hobart).

Dr E.Luis, National Institute for Science and Technology, Philippines - R & D Research Management Training Program, conducted by CSIRO under auspices of ASEAN Australian Economic Cooperation Program (AAECP).

The following scientists conducted collaborative research as part of ACIAR Projects: Mr P.Poerwardi and Miss N. Indriati, Research Institute for Fisheries Technology, Jakarta, Indonesia - ACIAR Project 8304 'Spoilage in dried fish'; Mr G.Atkinson and Mrs C.M.Warisaiho, Department of Primary Industry, Konedobu, Papua New Guinea - ACIAR Project 8354 'Transport and storage of fresh fruit and vegetables in PNG' (particularly mixed loads); Mr Lam Peng Fatt, Malaysian Agricultural Research and Development Institute (MARDI), Kuala Lumpur, Malaysia - ACIAR Project 8356 'Physiological, chemical and storage characteristics of mangoes in South-East Asia' (mainly carried out at Division's Postharvest Laboratory at CSIRO Darwin Laboratories, NT); Dr H.Nair, Universiti Malaya, Kuala Lumpur, and Dr Tan Soon Chye, Department of Biochemistry, Universiti Kebangsaan Malaysia, Selangor, Malaysia - ACIAR Project 8355 'Postharvest physiology and technology of bananas, and its application to some other tropical fruits in South-East Asia'.

Messrs D.Burford and H.Rahman, School of Fisheries, Australian Maritime College, Launceston, Tasmania - practical work at TFRU (Hobart) related to studies for Post-Graduate Diploma in Fisheries Technology.

At MRL:

Dr D.A.Ledward, Department of Applied Biochemistry and Food Science, University of Nottingham, Sutton Bonington, UK - research on colour and stability of beef and sheep muscles after effective electrical stimulation.

The Division is providing facilities (and supervision) at its Laboratories for students from tertiary institutions (including Universities of Sydney and New South Wales, Macquarie University, NSW Institute of Technology and Royal Melbourne Institute of Technology Ltd) to undertake the experimental components of their degree programs and to learn new techniques. In some instances students are being assisted financially by Divisional Post-Graduate Studentships.

Visitors

The Division welcomed many other visitors for brief periods. They included:

Mr E.Bridson, Oxoid (UK); Messrs J.Oakton, Managing Director, Oxoid (UK) and J.Markwell, Oxoid (Australia).

Dr C.Leng, Unilever Research, Port Sunlight Laboratory, Merseyside, UK.
Dr K.T.Taylor, Kratos, Manchester, UK.
Dr G.Heinz (Federal Republic of Germany) and Dr G.Ferri (Italy), Government veterinarians, and Dr J.Wilson, EEC representative.
Dr J.B.De Groot, EKRO B.V., Apeldoorm, Netherlands, and Dr E.Lamboy, Dutch Meat Research Institute, Zeist, Netherlands.
Mr H.Voges, Ludwig Spies, Hamburg, West Germany.
Mr K.Schmidt, Georg Boden & Co GmBH, Hamburg, West Germany.
Professor G.Lorentzen, University of Trondheim, Oslo, Norway.
Professor J.Raa, University of Trømso, Norway.
Dr L.Denys, Carlsberg Research Center, Copenhagen, Denmark.
Dr J.Dyerberg, Department of Clinical Chemistry, Aalborg Hospital, Denmark.
Miss N.Guyon, ENS.BANA, University of Dijon, France.
Dr O'Kabe, United Nations Organization.
Mr Paisan Loaharanu, Food Preservation Section, Joint FAO/IAEA Division of Isotope and Radiation Applications of Atomic Energy for Food and Agriculture Development, International Atomic Energy Agency, Vienna, Austria.
Dr R.A.Greenberg, Associate Director, American Council on Science and Health, New York, USA.
Professor A.J.Maurer, Poultry Science Department, University of Wisconsin-Madison, Madison, Wisconsin, USA (currently at University of Philippines).
Dr K.H.Norris, USDA, Maryland, USA.
Mr D.A.Borden, Durkee Industrial Foods, Cleveland, Ohio, USA.
Dr C.S.Yanoni, IBM Research Laboratory, San Jose, USA.
Professor J.W.Doane, Liquid Crystal Institute, Kent State University, Ohio, USA.
Professor W.Thompson, Department of Botany, University of California, Riverside, California, USA.
Miss L.G.McClure, Department of Biological and Agricultural Engineering, North Carolina State University, USA.
Dr R.Paull, University of Hawaii, Honolulu, Hawaii, USA.
Dr P.Gitelman, Food Technologist, Canada.
Mr P.Davies, Food Processing Development Centre, Alberta, Department of Agriculture, Canada.
Dr Zheng Zhe Rong, Institute of Agronomy, Beijing, People's Republic of China.
Professor Lu Liang Shu and delegation from Chinese Academy of Agricultural Sciences, People's Republic of China.
His Excellency Mr He Kang, Minister of Agriculture, Animal Husbandry and Fisheries, People's Republic of China, and colleagues.
Mr Guo Pu-Keng (leader) and delegation, Guangdong Science and Technology Commission, People's Republic of China.
Mrs Sheng Gin Dong, Deputy Director (Engineer), Food & Fermenting Industry Research Institute of Guangdong Province, and Mrs Hsu Shen Jing, Chemical Engineer & Section Chief, Science & Technology Department, Guangdong Provincial Light Industry Bureau No.1, Guangzhou, People's Republic of China.
Dr H.Shiota, Shiono Koryo Kaisha Ltd, Osaka, Japan.
Personnel from Japanese meat industry.
Miss L.G.Nallana, ACIAR Liaison Officer, Philippines.
Professor T.P.Acevedo, University of the Philippines.

Dr M.C.C.Lizada, Postharvest Horticulture Training and Research Centre, University of the Philippines, Los Baños, Philippines.
Mr Venkatesan, Australian High Commission, New Delhi, India.
Dr Ashair Taqvi, Vice-Chairman, Pakistan Export Bureau.
Dr R.E.Timms, Malaysia Oil Refiners.
Mr A.Shafri bin Man, Director of Administration, MARDI, Malaysia.
Dr L.Fredricks, Director, ASEAN Food Handling Bureau, Malaysia.
Miss J.Putiwaranart, Veterinary Public Health Section, Disease Control Division, Department of Livestock Development, Bangkok, Thailand.
Mr B.J.Gorddard (Project Manager) and Research Directors, World Bank's National Agricultural Research Project in Thailand.
P.Rattagool, S.Sukpratoom, J.Yamprayoon and R.Pruthiarenum, Fishery Technology Development Division, Department of Fisheries, Bangkok, Thailand.
Miss P.Methatif, Fishery Technological Development Division, Bangkok, Thailand.
Group of 10 Regional Directors of Agriculture, Thailand.
Mr Apichai Sunchindah, ACIAR Liaison Scientist, Bangkok, Thailand.
Mr Paul Yap Yeow Pen and Mrs Ong Kim Lian, Chemical Process Technology Department, Singapore Polytechnic, Republic of Singapore.
Group of rice millers from Thailand and Vietnam.
His Excellency Mr Nguyen Ngoc Triu, Minister for Agriculture, and colleagues, Vietnam.
Dr J.B.Lowrey, CSIRO Project for Animal Research Development, Indonesian Research Institute of Animal Production, Bogor, Indonesia.
Dr Syaifullah, Department of Horticulture, Pasar Minggu, Indonesia.
Mr J.F.Martin, Native Land Development Corporation, Fiji.
Professor D.K.Blackmore, Department of Veterinary Science, Massey University, Palmerston North, New Zealand.
Dr P.T.Holland, Ruakura Soil and Plant Research Station, Ministry of Agriculture and Fisheries, Hamilton, New Zealand.
Dr J.Love, DSIR Chemistry Division, Lower Hutt, New Zealand.
Dr P.A.Monro, Chemical Materials Engineering Department, University of Auckland, New Zealand.
Dr J.Mitchell and Mr R.Norris, Applied Chemistry Section, DSIR Chemistry Division, Auckland, New Zealand.
Dr L.A.McLachlan, DSIR Institute of Nuclear Sciences, Lower Hutt, New Zealand.
Professor P.T.Callaghan, Biophysics Department, Massey University, Palmerston North, New Zealand.
Drs J.R.McWilliam (Director) and G.Persley (Program Coordinator), Australian Centre for International Agricultural Research (ACIAR).
Dr R.F.Simpson, Chemistry Group, Australian Wine Research Institute, Glen Osmond, South Australia.
Dr A.Mackay-Sim, University of Adelaide, South Australia.
Members of Food Industry Council of Australia.
Members of New South Wales Dried Fruits Board.

His Excellency, Mr Nguyen Ngoc Triu, Minister for Agriculture, Vietnam, visiting FRL

Foreign aid activities

In July 1984 Dr R.L.Johnson (FRL) visited Fiji at the request of the Australian High Commission to assist the Fiji Citrus Producers Ltd with a problem of bitterness in citrus.

During a visit to the Philippines, Indonesia, Thailand, Malaysia and Singapore (September-October 1984), Dr D.Graham (FRL) was an invited speaker at the 4th Symposium of the Federation of Asian and Oceanian Biochemists, Manila, Philippines, and was leader of a team commissioned to review the ASEAN Postharvest Horticulture Training and Research Centre, Los Baños, Philippines. In November-December 1984 Dr Graham returned to Indonesia to present the review report to the ASEAN Subcommittee on Food Handling.

Mr I.A.Mathieson (FRL) visited Thailand, Philippines, Indonesia, Singapore, Brunei and Malaysia (October-November 1984) as a consultant on computer systems to the ASEAN Food Handling Bureau (ASEAN Postharvest Exchange Regional Information Network Project).

In October 1984, at the request of the Australian Development Aid Bureau (ADAB), Dr A.G.Lane (FRL) took part in a

group meeting of the ASEAN Project on Food Waste Materials and in the Second ASEAN Workshop on Biogas Technology, Kuala Trengganu, Malaysia (under auspices of ASEAN Australia Economic Cooperation Program).

Mr W.F.Spooncer (MRL) visited Singapore (October-November 1984) to take part in training courses in laboratory techniques of microbiological and chemical safety, and quality control for ASEAN laboratory personnel of the ASEAN Food Handling Bureau, Veterinary Public Health Institute, Primary Production Department, Singapore.

Dr W.B.McGlasson (FRL) visited Bhutan and India in November 1984 as part of an ADAB Aid to Bhutan Project on Postharvest Horticulture Handling and Storage.

In February-March 1985, Mr P.W.Board (FRL) undertook a consultancy (funded by a grant from the World Bank) to the Laboratorio Tecnologico de Uruguay (LATU), to provide advice on the suitability for processing of local varieties of fruits and vegetables. In May-June 1985 Mr Board visited the Philippines, Thailand and Malaysia at the request of the Food Quality and Standard Service of FAO to discuss the preparation of a booklet 'Guidelines for Quality Control in Fruit and Vegetable Processing'.

The Division continues to strongly support the Australian Centre for International Agricultural Research (ACIAR), and in addition to initiating and collaborating in several projects, officers have made frequent visits to South-East Asian countries. Dr J.I.Pitt (FRL) visited Indonesia in January 1985 (project on spoilage of Indonesian dried fish); Dr G.R.Chaplin (FRL) visited the Philippines, Thailand, Malaysia and Singapore in February 1985 (mango research), and in April-June 1985 attended the Second International Symposium on the Mango, Bangalore, India, and visited Thailand and Malaysia to continue collaboration on mango research; Dr N.L.Wade (NSW Department of Agriculture) visited the Philippines in February-March 1985 (research on bananas); Mr K.J.Scott (NSW Department of Agriculture) made three visits of 2-4 weeks' duration to Papua-New Guinea to collaborate with the PNG Department of Primary Industry (fruit and vegetable handling and transport studies).

In September 1984 Dr R.M.Smillie (FRL) visited the People's Republic of China to investigate a possible ACIAR project on chilling injury in rice.

Work overseas

Many officers of the Division travelled overseas on duty during the year. The great majority were on official non-quota visits, for which all or most of the travel expenses are provided by other organizations. Brief details of countries visited and conferences attended are given below.

Dr J.H.B.Christian (Chief): UK, Europe (October-November 1984) - Attended (as Chairman) General Meeting of International Commission on Microbiological Specifications for Foods (ICMSF) (West Berlin, FDR), meeting of Commission's Editorial Committee and meeting of *Ad hoc* Committee on Control of Salmonellosis (Copenhagen, Denmark). Philippines (February 1985) - Invited speaker, ASEAN Food Conference 85, Manila.

Mr L.L.Muller (Assistant Chief): Japan, UK, USA (October-November 1984) - Discussions with existing and potential collaborators on cheese development projects.

Dr C.J.Brady (FRL): USA, UK, Israel, Malaysia (January-December 1984) - Collaborative research on biochemistry of senescence in fruit tissues, at University of California, Davis; attended Gordon Conference on Senescence in Plants (New Hampshire) and Annual Meeting of American Society of Plant Physiologists (Davis, California).

Dr R.L.McBride (FRL): New Zealand, USA, Canada (December 1983-October 1984) - Collaborative research at University of California, San Diego, California, and Yale University, New Haven, Connecticut; attended American Institute of Food Technology Conference (Anaheim, California), American Society for Testing and Materials Meeting of Committee E-18 Sensory Evaluation (Denver, Colorado), Annual Meeting of Association for Chemoreception Science (Sarasota, Florida), 1984 Gordon Conference on Olfaction and Taste (New Hampshire), and the Annual Meeting of the American Psychological Association (Toronto, Canada).

Dr D.G.Bishop (FRL): USA, Europe (February-November 1984) - Collaborative research at ARCO Plant Cell Research Institute, Dublin, California, USA; attended Sixth International Symposium on the Structure, Function and Metabolism of Plant Lipids (Neuchatel, Switzerland).

Dr J.I.Pitt and Miss A.D.Hocking (FRL): USA (July-August 1984) - Attended Workshop on 'Standardization of Methods for the Mycological Examination of Foods' (Boston, Massachusetts) and Gordon Research Conference on 'Microbiological Safety of Foods' (Plymouth, New Hampshire) (under auspices of US/Australia Cooperative Science Program).

Dr J.I.Pitt (FRL): Netherlands, UK (May 1985) - Attended First International Workshop on *Penicillium* and *Aspergillus* (Amsterdam).

Dr W.R.Shorthose (MRL): USA, UK, Europe (August-October 1984) - Attended 30th European Meat Research Workers Conference (Bristol, UK) and American Society of Animal Science Conference (Missouri, USA).

Dr A.F.Egan and Mr B.J.Shay (MRL): Europe, UK (September-October 1984) - Attended 30th European Meat Research Workers Conference (Bristol, UK). Dr Egan also attended a meeting of ISO Working Group - Enumeration of lactic acid bacteria (Bristol, UK).

Dr F.H.Grau (MRL): New Zealand (August 1984). Attended N.Z. Meat Industry Conference.

Mr G.L.J.Wescombe (MRL): New Zealand (September 1984) - At meeting held at Meat Industry Research Institute of New Zealand Inc. (MIRINZ), Hamilton, demonstrated water jet deboning of mutton carcasses.

Dr R.J.Park (MRL): Europe, UK, USA (September-October 1984) - Attended 3rd European Congress on Biotechnology, Munich, West Germany.

Dr W.G.Murrell (FRL): Japan, USA (August-October 1984) - Attended Ninth International Spores Conference (Asilomar, California), meeting of FAO/WHO Working Group on Microbiological Examination and Specifications of Canned Foods, and meeting of Food Hygiene Committee of Codex Alimentarius Commission (Washington, DC).

Dr J.A.Lindsay (FRL): Japan, USA (August-October 1984) - Presented series of lectures on spore heat resistance and toxins, at University of Osaka, Japan; attended Ninth International Spores Conference (Asilomar, California, USA). USA (March 1985) - Guest Speaker at Symposium on Bacterial Spore Resistance, 85th Annual Conference of American Society of Microbiology, Las Vegas.

Dr G.A.Bell (FRL): USA (October-November 1984) - Attended meeting of Neurosciences Society, Los Angeles.

Dr R.W.Sleigh (FRL): Japan, Europe, UK, USA, Canada (October 1984-October 1985) - Collaborative study of protein separation schemes, Institute of Biochemistry, University of Uppsala, Sweden; to attend 13th International Congress of Biochemistry, Amsterdam, Netherlands. (CSIRO Overseas Fellowship Scheme).

Mr B.P.Cain (MRL): USA - Visits to Roman Hruska US Meat Animal Research Center at Clay Center and Iowa Beef Packers Plant at Grand Island, Nebraska.

Dr A.G.Lane (FRL): Philippines (February 1985) - Invited speaker ASEAN Food Conference 85, Manila.

Dr R.F.Thornton (MRL): New Zealand (February 1985) - Attended N.Z. Society of Animal Production (Inc.) Conference, Palmerston North.

Dr B.A.Cornell (FRL): USA (February-March 1985) - Attended 29th Annual Meeting of American Biophysical Society, Baltimore, Maryland.

Mr G.L.Ford (FRL): UK, Europe, Thailand (March-April 1985) - Attended Second International Congress on Essential Fatty Acids and Prostaglandins, London, UK.

Dr D.G.Laing (FRL): USA (April-May 1985) - Attended 7th Annual Meeting of Association for Chemoreception Sciences, Sarasota, Florida.

Dr R.R.Hull (DRL): Europe, Eire, UK, USA (April 1985-February 1986) - Collaborative research on cheese starter technology at various research centres, including laboratories of Chr.Hansens, Copenhagen, Denmark (six months) and Milwaukee, Wisconsin, USA (three months). (CSIRO Overseas Fellowship Scheme).

Dr R.L.Hood (FRL): USA (April-May 1985) - Attended Annual Meeting of Federation of American Societies for Experimental Biology, Anaheim, California.

Dr R.M.Smillie (FRL): Japan (April-May 1985) - Attended Conference on 'Instrumentation for Research in Physiological Ecology', Tokyo.

Dr B.V.Chandler (FRL): USA (April-May 1985) - Attended American Chemical Society Symposium on Adulteration of Fruit Juices, Miami Beach, Florida.

Dr J.N.Olley and Mr H.A.Bremner (FRL): New Zealand (April 1985) - Attended three-day Processing Seminar conducted by DSIR as part of Fishing Exhibition FISHEX 85, Nelson.

Dr G.S.Sidhu (FRL): USA, Canada, UK, Europe, Pakistan, India (May-December 1985) - Collaborative research on saponins at Oregon Regional Primate Research Center, Beaverton, Oregon, USA.

Drs R.L.Johnson (FRL) and V.H.Powell (MRL) and Messrs I.J. Eustace and B.J.Shay (MRL): New Zealand (May 1985) - Attended Joint AIFST/NZIFST Convention 'FOODANZA '85', Christchurch.

Mr F.D.Shaw (MRL): New Zealand (May-June 1985) - Visits to meat research centres.

Dr J.G.Zadow (DRL): New Zealand (October 1984 and May 1985) - Presented papers at the seminars Pak 90, Auckland and AIFST/NZIFST 'FOODANZA '85', Christchurch.

Dr E.H.Ramshaw (DRL): USA, Europe (June 1985) - Attended Electroanalytical Symposium (Chicago, USA) and 21st International Symposium on Advances in Chromatography (Oslo, Norway).

Dr D.G.Oakenfull (FRL): UK, Europe, India (June-September 1985) - Attended Conference on Food Gums and Stabilisers (Wrexham, UK) and XIII International Congress of Nutrition (Brighton, UK).

Liaison and extension

Close liaison was maintained with the Technical Services Group of the Australian Dairy Corporation, Asian Dairy Industries (H.K.) Ltd and the Australian Dairy Culture Association.

MRL's extension involving training and education programs at the Laboratory, at Industry Schools, seminars and on-the-spot instruction at meatworks, continued at a high level. Officers participated in the Australian Meat and Live-Stock Corporation Quality Assurance courses held in various States.

In May 1985, with the assistance of a grant from the Department of Resources and Energy under its National Industrial Energy Management Scheme (NIEMS), a seminar 'Cost Effective Energy Use in Meat Processing' was held in Brisbane; a one-day workshop 'Chilling Hot Carcasses and Sides' was held immediately after the seminar.

Officers of the MRL Industry Section prepared and attended a stand with an extension and advisory theme at the International Meat Trades Fair in Melbourne.

A further Workshop in the Inter-Divisional Program on Long Chain Fatty Acids was held in Adelaide in June 1985, involving CSIRO officers and representatives from various govern-

ment departments and medical centres in Victoria, South Australia and Western Australia.

Officers from FRL took an active part in the organization of the first Mango Research Workshop in Australia, held at Cairns, Qld in November 1984, and the Australian Society for the Study of Animal Behaviour Symposium 'The Perception and Mechanisms Underlying Simple and Complex Odour Mixtures' held at Bundanoon, NSW in May 1985.

An extra-mural grant was made by the Division to the Department of Anatomy and Biology as applied to Medicine, Middlesex Hospital Medical School, University of London, UK, to support collaborative research on the measurement of forces and distances in the adhesion of living cells.

Following attendance at the annual meeting of the Australian Society for Microbiology Inc. in Perth, WA, in May 1985, Divisional officers took part in a Food Industry-Microbiology Symposium and visited several firms involved in chicken processing, seafood processing and smallgoods manufacturing.

Following requests from the food industry and the Department of Primary Industry, examinations were organized for persons who wished to become Approved Persons for the evaluation of heat sterilization processes for low-acid canned foods.

Staff of TFRU contributed to the seminar 'The Australian Fishery Industry - Today and Tomorrow' held on 10-12 July 1984 at the Australian Maritime College, Launceston, Tas.

Officers of FRL provided a series of food pilot-plant exercises for students in the Master of Applied Science (Food Engineering) program of the University of New South Wales.

DRL works in general collaboration with the Food Technology Unit of the Royal Melbourne Institute of Technology Ltd and several students used DRL as a base for undertaking major projects. DRL staff are also involved with courses at the VCAH Gilbert Chandler Campus, Vic.

DRL staff assisted with the organization of a CSIRO Inter-Divisional Seminar on 'Process Development in CSIRO' held in December 1984, which provided a workshop for interchanging ideas on process development and will provide the basis for further more specialized inter-Divisional seminars.

A demonstration of the sunflower protein extraction process was organized at the Gilbert Chandler Institute of Dairy Technology, Werribee, Vic., in October 1984. Key industry personnel were invited to attend and the commercial possibilities for the product were discussed.

An informal Taste-Testing Workshop was held at DRL dealing with problems of designing and analyzing taste-testing experiments.

DRL, in conjunction with the Gilbert Chandler Institute of Dairy Technology, held a Seminar on Reverse Osmosis (RO) to

publicize the research findings and applications of RO. DRL staff have also been involved with the Australian Society of Dairy Technology in arranging a Seminar on Specialty Cheeses for Australia.

Staff at DRL took part in the 'New Horizons Seminar', organized by the Australian Dairy Corporation and attended by senior management from every dairy cooperative in Australia.

At FOODTEC'85, a public exhibition of food processing and assorted equipment and processes held in Sydney from 24-27 June 1985, the Division exhibited a counter-current extractor developed at FRL and being commercialized by Bioquip Australia Limited.

Visitors to the Division's stand at FOODTEC'85

FOOD RESEARCH LABORATORY

APPLIED FOOD SCIENCE

The research program of the Applied Food Science Group is designed to develop new processes, equipment, products and knowledge for use by the Australian food processing industry. The projects cover many aspects of the processing, packaging and transport of foods, and of food engineering, and include the anaerobic fermentation of processing wastes.

Many of the projects arise directly from requests and inquiries from the Australian food processing industry and related bodies. Others are undertaken because they seem likely to meet the future needs of the industry. The staff of the Group has frequent contact with technical and managerial staff in the food industry and also with some of the regulatory bodies and teaching institutes.

Processing and engineering

Counter-current extraction (CCE)

D.J.Casimir
D.J.Noice
W.C.Osborne
D.Watson

The Division continued to collaborate with Bioquip Australia Pty Limited. This company is licensed to manufacture and sell the CSIRO CCE, which is now patented in 22 countries.

Following the satisfactory performance of the first commercial CCE installed in South Australia, a second unit was installed early in 1985. These machines were used to extract apple and pear juices and some citrus juice was also produced. Two other commercial CCE were installed during the year. One, in NSW, is used to rejuvenate peat moss from mushroom-growing beds, and the other, in New Zealand, to produce apple and black currant juices.

De-watered solids leaving a commercial counter-current extractor

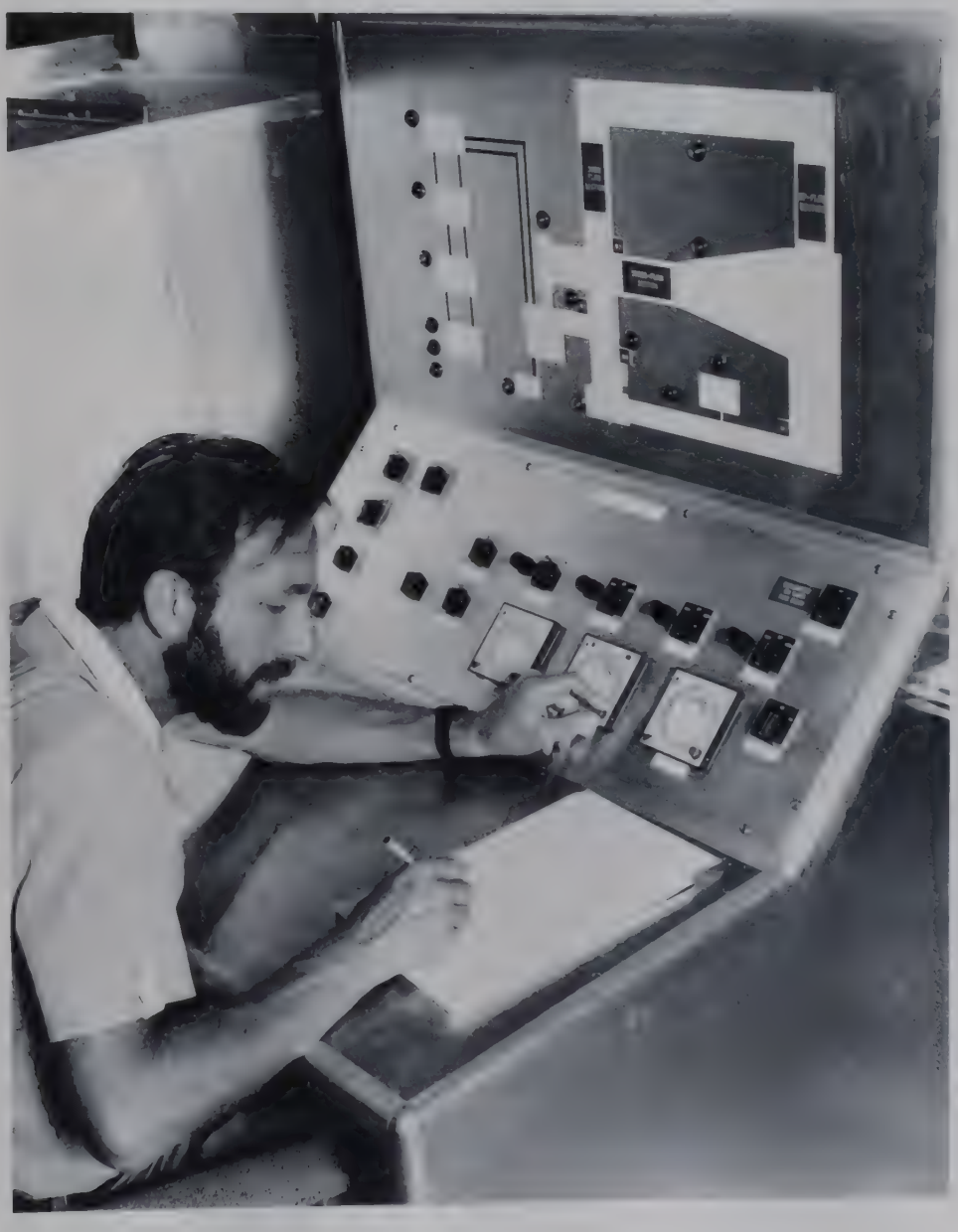
New concepts for the extraction of soluble material, other applications for the CCE process, optimization of the commercial operation and the development of microprocessor control are being investigated.

Experimental dehydrator

P.W.Board
R.J.Coghlan
L.Lindsey
R.J.Steele

An experimental dehydrator was built by FRL's Engineering Workshop. Temperature, humidity and air speed can be controlled over wide ranges. The set-point for the controllers may be changed automatically using an HP 3054 Data Logger. The dehydrator has provision for cross-flow, down-flow and up-flow drying, including fluidized drying.

The effects of sulphur diozide and other pretreatments on the rate of dehydration and the quality of dried foods will be studied.



Adjusting the set-point for the temperature in the experimental dehydrator

Product studies

Headspace sulphur dioxide and non-enzymic browning

H.R.Bolin[1]
R.J.Coghlan
R.J.Steele

Dried apples were used to study the relationship between pH, sulphur dioxide content and non-enzymic browning. Headspace sulphur dioxide and carbon dioxide in packages of dried apples during storage were monitored by a gas chromatographic technique. The extent of non-enzymic browning was more closely correlated to the concentration of sulphur dioxide in the headspace than to either the free or total sulphur dioxide in the apple. The method for determining free sulphur dioxide, which is commonly accepted as measuring only inorganic sulphite, was found to measure the bound sulphite that was rapidly released under acid conditions.

Use of plant proteins in foods

I.L.Batey[2]
P.I.Bath
P.W.Board

A procedure was developed for manufacturing enzyme-modified gluten (EMG) on a small commercial scale. This product, in the form of a creamy coloured, readily dispersible powder, was successfully used as an ingredient in a wide range of foods. It retains its properties during storage for months under ambient conditions. The commercial process for manufacting EMG is being modified to give a product with an even wider range of applications as a food ingredient.

Peanut allergens

D.Barnett
R.W.Burley
M.E.H.Howden[3]

Sera from persons who are allergic to peanuts frequently give IgE-based reactions to extracts of a number of other legume proteins. It was found by a radio-allergosorbent inhibition method that these reactions are largely due to cross-reaction and not to separate sensitization.

The identity and nature of the proteins responsible for this cross-reaction are being investigated, using the lectin from garden peas as a model. Several other legume lectins, with some amino-acid sequence homology to the pea lectin, were also studied to elucidate the cross-reaction mechanism.

Sorption isotherms of tropical products

J.E.van S.Greve[4]
D.A.Jamieson
A.K.Sharp

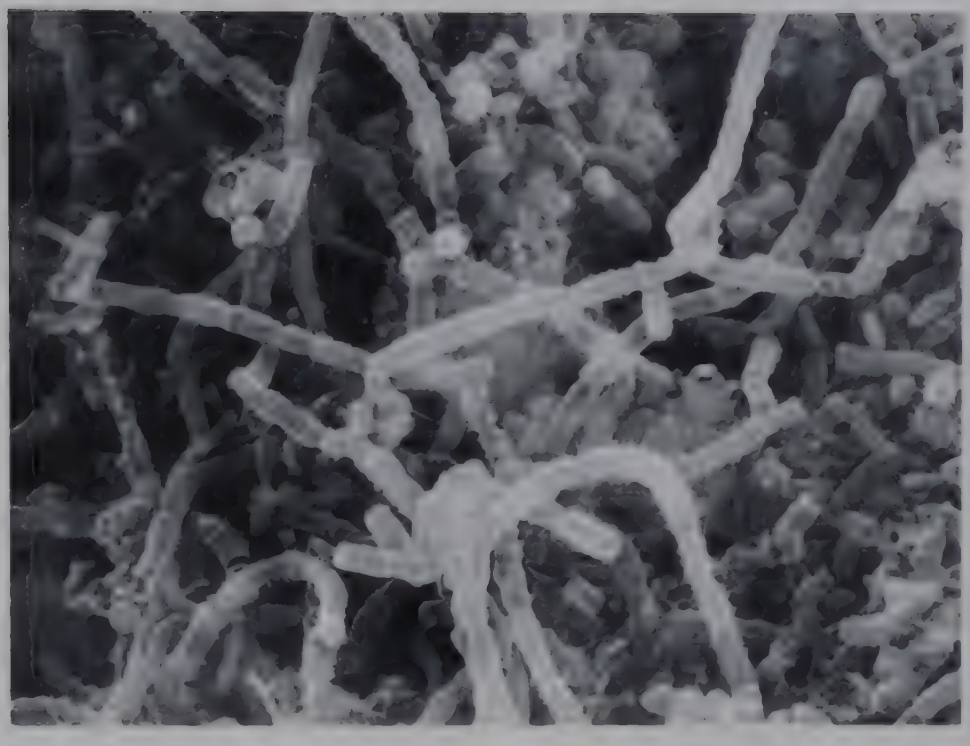
Sorption isotherms for cocoa and coffee beans, and for Pandanus nuts grown in Papua New Guinea, are being measured. With these data, conditions for storing and transporting these products with minimum loss of quality can be defined.

Waste utilization and disposal

Anaerobic treatment of waste water from dried fruits packing houses

P.Gwatkin
A.G.Lane

Laboratory-scale trials established that an upflow anaerobic sludge blanket (UASB) process performed better than an anaerobic filter, removing 94% of the chemical oxygen demand (COD) at retention times down to 28 h. A pilot-scale digester (capacity 400 l) installed at a packing house for dried vine fruit in Mildura is giving a better performance, removing up to 94% of the COD from 500-600 l of waste water per day (retention time 16-19 h). Highly granular sludge developed, having excellent settling properties and high biological activity. The granules consist of dense masses of diverse bacteria. Trials with the pilot-scale digester are now aimed at minimizing the cost of chemicals added for pH control and as microbial nutrients, and at establishing the stability of the process under industrial conditions.



Scanning electron micrograph showing bacteria from an anaerobic digester treating vine fruit effluent (x2500)

Production of methane from food wastes

B.R.Crowley
A.G.Lane

Press liquors are generated during production of livestock feed from citrus peel. Their high COD (up to 150 g COD/1) makes them attractive as feedstock for methane production, provided that the levels of citrus peel oil are reduced by air stripping to levels below which the oils are toxic to the process. The concentrations of nitrogen and phosphorus in the press liquors were adequate for digestion.

Anaerobic digestion of citrus peel press liquors by the UASB process was studied in reactors of 20-1 capacity operating at a hydraulic retention time of 5 d and with a recycle flow of 22 1/d. Stable, long-term performace was obtained at feed strengths up to 60 g COD/1, corresponding to an organic load of 12 kg COD/m^3 d. The reason for digester failure at higher loading rates has not been determined but it was not due to deficiency of nitrogen, phosphorus, trace metals or sulphide.

Phleomycin and bleomycin production

A.G.Lane
J.M.Myers

Production of the potential anti-cancer drugs bleomycin and phleomycin by *Streptomyces verticillus* fermentation was terminated; these materials were required for evaluation by the CSIRO Division of Molecular Biology.

Packaging

Corrosion of tinplate

P.W.Board
L.Lindsey
R.J.Steele

The investigation to identify factors influencing the rate of corrosion of tinplate by food products of low water activity continued. The importance of the water activity-product mobility interaction is being assessed.

Effect of copper on corrosion of tinplate

R.J.Coghlan
R.J.Steele

The effect of low levels of copper in foods on the corrosion of lacquered and unlacquered tinplate cans was examined. Copper aggravated pitting corrosion in lacquered cans; at higher levels of copper the attack was concentrated at a few points while with low concentrations of copper many areas in the can corroded. Copper in plain cans increased the rate of detinning.

External corrosion of tinplate cans

P.W.Board
P.Cavanough[5]

Work in collaboration with the Armed Forces Food Science Establishment on the external corrosion of tinplate cans was expanded to include field trials at the Joint Tropical Trials and Research Establishment, North Queensland. The problem of thermophilic spoilage of canned foods in field storage in the tropics and its control with nisin is also being investigated. The trials have already shown that improved external lacquers are needed for canned foods intended for field storage in wet tropical areas.

Singlet oxygen in polymer matrices

R.V.Holland
R.A.Santangelo

Studies of the diffusion and reaction rates of photochemically produced singlet oxygen in packaging films continued. Several applications of this work have already been realized, including a device for measuring oxygen permeability and an oxygen scavenging film.

Synthesis of photochemical oxygen scavengers

R.V.Holland
R.A.Santangelo

Several reversible singlet oxygen acceptors were synthesized; they absorb singlet oxygen under ambient conditions, and release it at slightly higher temperatures. These materials are useful for absorbing oxygen quantitatively, and for the kinetic and diffusion measurements described above. They may also be used to provide known amounts of singlet oxygen independent of photochemical reactions.

Measurement of permeability

R.V.Holland
R.A.Santangelo

The development of a technique for measuring oxygen permeability of packaging films using singlet oxygen led to similar methods for measuring the permeation of water vapour and other volatile materials, such as simple odorants. These techniques are now being applied to complex odours, such as that from coffee, where the various compounds constituting the odour have different permeation rates in the test system.

Photochemical scavenging of oxygen from enclosed systems

K.Y.Cho[6]
M.L.Rooney

Polymer systems capable of removing oxygen from closed containers are being developed in collaboration with an industrial partner. Initially, the work is directed at microbiological aspects of the food industry but this phase will be followed by food packaging applications once the technical problems associated with food contact are overcome.

Food transport

Transport of onions fan-ventilated with ambient air

A.R.Irving
A.K.Sharp

Increasing quantities of onions are being exported from Australia at ambient temperature in fan-ventilated general-purpose containers and, more recently, in 'porthole' insulated containers which are fitted with an exhaust fan to give 35 air changes/h. The general-purpose containers had inlet vents cut at floor level into the side walls at the end containing the door. Following earlier field studies the distribution of air in both types of container was

measured under test room conditions. It was found that the position of the floor-level inlet vents was not critical in general-purpose containers fitted with a 100-mm deep false floor.

Previous studies with fan-ventilated 'porthole' containers had shown discrepancies between air distribution measurements based on the thermal response of the stow to a step change in ambient air temperature, and on direct measurements of air velocity. Air distribution was found to be substantially uniform so there is no need for a perforated floor overlay or for other devices to help distribute the air.

Prevention of condensation in containers

J.E.van S.Greve[4]
A.K.Sharp

Passive ventilation is becoming accepted as an adequate measure to prevent condensation damage to coffee beans during shipment, and in experimental shipments it has also been shown to be effective with cocoa beans. In further trial shipments of coffee the performance of CSIRO Ventainer ventilated containers was compared with that of commercial ventilated and non-ventilated containers and fan-ventilated 'porthole' insulated containers stowed both on deck and in the hold. The containers were shipped from Lae, Papua New Guinea, to Sydney *via* Melbourne. In spite of the cold weather in Melbourne there was little condensation in the ventilated containers. Taste testing of samples of the coffee taken before and after the voyage showed little or no loss of quality.

Using a tracer gas technique, high ventilation rates were observed in containers stowed on deck. Much lower ventilation rates were measured after discharge from the ship, when the containers were in still air.

In-transit cold sterilization of fruit fly

D.B.Drewitt-Smith
A.R.Irving
C.J.Rigney[7]
A.K.Sharp

As an alternative to treating fruit wich chemical fumigants such as ethylene dibromide (EDB), all life stages of fruit fly can be killed by prolonged exposure to low temperatures. Effective sterilization requires fruit temperatures to be held below 2°C for 16 d, or at lower temperatures for shorter periods. The fruit must not be frozen and chilling injury must be avoided. In-transit sterilization is well established in conventional refrigerated ships and in 'porthole' containers carried in cellular container ships. The aim of this static trial was to determine whether effective cold sterilization could be achieved in integral refrigerated containers subjected to high ambient temperatures.

Two similar top delivery integral refrigerated containers with high air circulation rates were loaded with cartons of Queensland oranges, some of which contained cultures of Queensland fruit fly. One container was stored in the open at ambient temperatures ranging around 20°C, and the other was placed in a test chamber at 35°C. With some modifications, a temperature range of 2 deg C was maintained throughout the container for 16 d, and all fruit fly were destroyed, with minimal chilling injury to the fruit. In-transit cold sterilization is thus commercially feasible in high performance integral containers, provided that they are carefully prepared and adjusted daily throughout the treatment period.

CHEMICAL BASES OF FOOD ACCEPTANCE

The aim of this program is to relate the chemical composition of foods to their flavour and other aspects of their acceptance by consumers. Projects include:

- Identification of the volatile compounds responsible for natural flavours and off-flavours in foods and for the off-flavours resulting from contamination during preparation, processing and storage.
- Study of the improvement of the quality of food by modifying its contents of desirable and undesirable constituents.
- Relating the senses of taste and olfaction to the consumer acceptance of food and applying such relationships to assessment of food quality.

Volatile flavours and mass spectrometry

Tomato flavours

J.H.Last
W.B.McGlasson
G.Stanley
F.B.Whitfield

Using a gas chromatograph (g.c.) with olfactory monitoring of the eluates, the headspace volatiles from the ripe fruit of the normally ripening tomato cultivar Rutgers were shown to contain between 6 and 10 compounds with aromas described as important in good fresh tomato flavour. By comparison, none of these compounds could be detected in the headspace volatiles of the mature non-ripening mutants *rin* and *nor*. Major qualitative and quantitative differences in the volatile content of these fruit were also observed.

The headspace volatiles of ripe fruit were also analysed by gas chromatography-mass spectrometry (g.c.-m.s.). Definitive mass spectra were obtained on all major components, including several of the compounds believed to be responsible for the fresh aroma of the Rutgers cultivar.

Off-flavours in dried fruit

L.Nguyen
K.J.Shaw
F.B.Whitfield

Mustiness in dried fruit is due to contamination of the fruit with 2,4,6-trichloroanisole (2,4,6-TCA) and 2,3,4,6-tetrachloroanisole (2,3,4,6-TeCA); the precursors of these compounds are the corresponding chlorophenols present in fibreboard packaging materials as minor components.

With the introduction to the dried fruit industry of fibreboard packaging materials with concentrations of chlorophenols at or below the levels recommended by the Division's investigations, reports of mustiness in export fruit have decreased dramatically.

The origin of chlorophenols in fibreboard was investigated and several materials used in recycled paper pulp were analysed for these compounds. Newsprint appeared to be a major source of chlorophenols.

Analyses of adhesives used in the manufacture of fibreboard and in the sealing of fibreboard boxes indicated that most

sources of chlorophenols had been eliminated from these materials. When chlorophenols were detected in an adhesive their origin was usually traced to the use of a biocide that contained a chlorophenol derivative as the active component.

Moulds in fibreboard

S.D.Levingston
C.R.Tindale
F.B.Whitfield

As part of the investigation of off-flavours in dried fruit, fibreboard samples from boxes containing fruit with a musty flavour were examined for xerophilic moulds. About 20 species have been isolated in total, of which *Scopulariopsis brevicaulis*, three species of *Penicillium* and one species each of *Eurotium*, *Aspergillus* and *Paecilomyces* all methylated 2,4,6-trichlorophenol (2,4,6-TCP) in Czapek broth at 25°C; *Aspergillus niger*, the only mould isolated from dried fruit, does not methylate 2,4,6-TCP under these conditions. Techniques were developed for the analysis of chloroanisoles and their precursors in culture media containing chlorophenols.

Studies are in progress to evaluate the individual performance of the methylating moulds in fibreboard containing chlorophenols under conditions of high humidity.

Threshold values of chloroanisoles

G.Kimm[8]
R.L.McBride
L.Nguyen
K.J.Shaw
F.B.Whitfield

To determine the taste threshold of 2,3,4,6-TeCA and pentachloroanisole (PCA) in dried fruit and plain buns, the chloroanisoles were either adsorbed onto the fruit or added to the flour mix before baking. Gas chromatography-multiple ion monitoring-mass spectrometry was used to determine the actual concentrations of the chloroanisoles in the adulterated food. A trained taste panel detected 2,3,4,6-TeCA and PCA in dried fruit at concentrations of 0.8 and 160 $\mu g\ kg^{-1}$ respectively, and in plain buns at 9.0 and 850 $\mu g\ kg^{-1}$ respectively. Detection limits for these compounds in aqueous solutions were previously determined as 0.1 and 10.0 $\mu g\ kg^{-1}$ respectively. By comparison, 2,4,6-TCA was detected in dried fruit, plain buns and aqueous solutions at concentrations of 0.2, 1.0 and 0.01 $\mu g\ kg^{-1}$ respectively.

Disinfectant off-flavour in flour

L.Nguyen
K.J.Shaw
F.B.Whitfield

Analyses of batter-coated foods with a disinfectant off-flavour showed contamination with 2,4-dichlorophenol and 2,4,6-TCP at concentrations which would produce a detectable off-flavour in these foods. The flour used in the preparation of the batter contained these chlorophenols in far greater concentrations. The plant manufacturing the flour occasionally used a hypochlorite solution for the sterilization of processing equipment. The storage tank for this solution was coated with fibreglass which contained the above contaminants in concentrations up to 12 000 $\mu g\ kg^{-1}$ each. Probable precursor of these compounds in the fibreglass was phenol from breakdown of bonding resin that had reacted with the hypochlorite solution to produce the chlorophenol contaminants.

Chloroanisoles in jute sacks

J.H.Last
D.C.Mugford[8]
K.J.Shaw
C.R.Tindale
F.B.Whitfield

Jute sacks used for the packaging of cereal grains and flours sometimes possess musty odours which can be imparted to the food. Analyses by g.c.-m.s. showed the tainted sacks contained 2,4-dichloroanisole, 2,4,6-TCA, 2,3,4,6-TeCA and PCA in high concentrations. The four corresponding chlorophenols were also detected but in slightly lower concentrations. 2,4,6-TCA and 2,3,4,6-TeCA, which have taste thresholds in baked products of only 1.0 and 9.0 $\mu g\ kg^{-1}$ respectively, were the principal tainting components of these sacks.

A possible link between the chloroanisoles and chlorophenols was provided by the isolation, from the tainted sacks, of moulds which readily methylate chlorophenols.

Apple volatiles

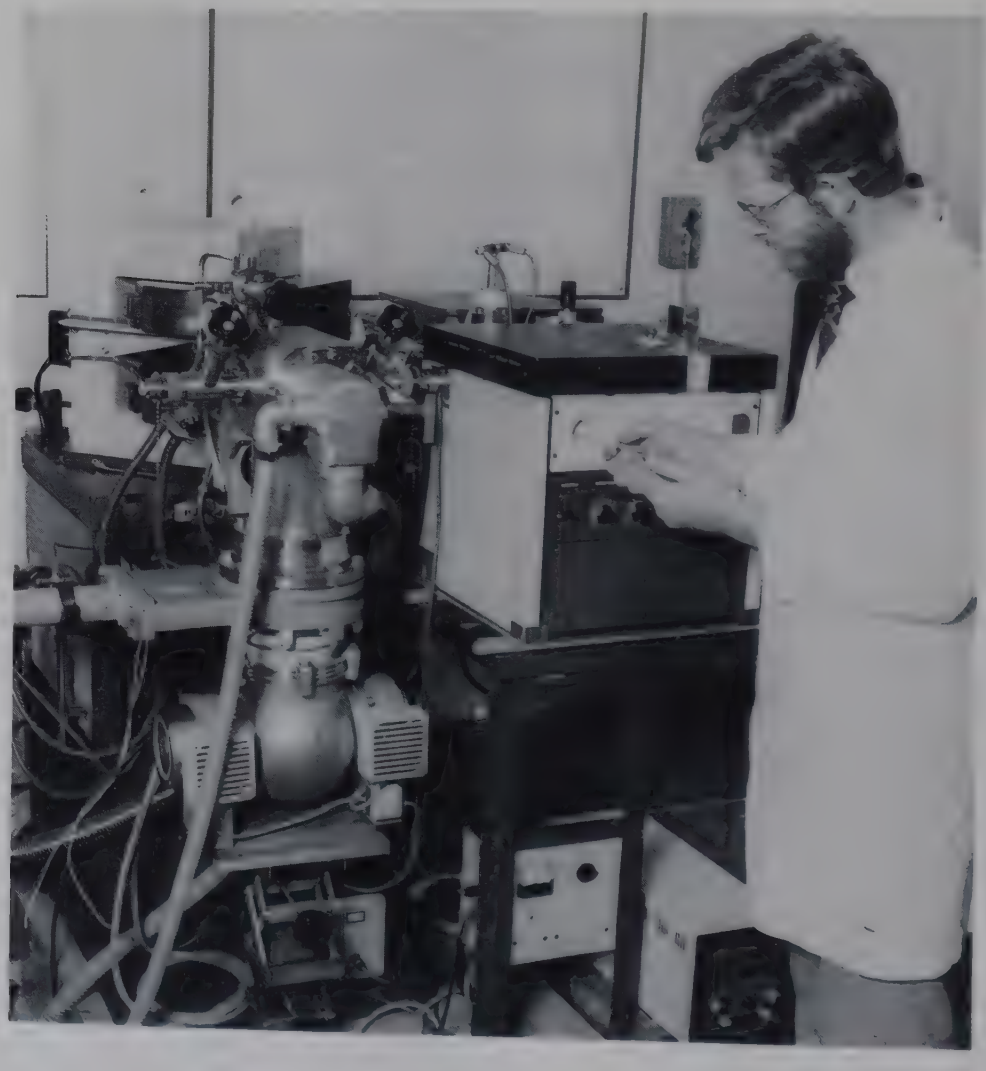
J.E.Algie
G.Stanley

The Atlas CH4 mass spectrometer, linked to g.c., was used in the analysis of the headspace volatiles of whole apples held under a variety of storage conditions; twenty major compounds were identified.

Mass spectrometry

K.J.Shaw
F.B.Whitfield

The MAT 311A mass spectrometer was used predominantly in the g.c.-m.s. mode. Considerable improvement was made in the application of the selected ion monitoring programs of the data system for the simultaneous analysis of 2,4,6-TCA, 2,3,4,6-TeCA and PCA in foods. Using 3,5-dimethyl-2,4,6-trichloroanisole as an internal standard, the three chloroanisoles could be measured in amounts as low as 0.1 μg kg^{-1} in dried fruit, fruit buns and fibreboard. This technique has also been used to measure 2,4,6-TCA in corks, wine and the Sydney water supply, and all three chloroanisoles in jute sacks.



Introducing an extract from a contaminated food for analysis by combined gas chromatography and mass spectrometry (MAT 311A)

Very high-resolution g.c. was achieved by the use of 50-metre flexible fused silica columns in the MAT 311A g.c.-m.s. facility in the analysis of volatile organic extracts

of tomatoes and wine. In the wine studies (undertaken in collaboration with the Australian Wine Research Institute), definitive spectra of 30 important compounds were obtained and two compounds that may contribute to the cork-taint of wine, geosmin and 2-methylisoborneol, were sought by selected ion monitoring.

The MAT 311A was used to confirm the identification, after derivatization, of chlorophenols isolated from foods and allied materials, and to establish the gross contamination of dried fruit with petrochemicals. Phenol and the three cresols were detected in tainted sugar solutions forwarded by a major refiner; the taint had been described as cresol-like.

The MAT 311A was also used in the direct insertion mode to obtain mass spectra of twelve microbial metabolites of bile acids for the Meat Research Laboratory.

Nuclear magnetic resonance (n.m.r.) spectroscopy

B.H.Kennett
F.B.Whitfield

The Brucker CXP 100 n.m.r. spectrometer continued to be extensively used in the high-resolution mode to obtain ^{1}H and ^{13}C n.m.r. spectra on microgram and sub-milligram quantities of pure organic compounds. Spectra were recorded for: natural and synthetic compounds important in food flavours, microbial metabolites of bile acids, natural polyunsaturated fatty acid esters, a series of products formed by the reaction of benzo-1,4-quinone with biogenic amines, and 2,4-dinitrophenylhydrazone derivatives of mono- and dicarbonyl compounds and Maillard reaction products. These spectra either facilitated the assignment of structures or confirmed structures assigned by other techniques.

Introducing a micro-sample of a natural flavour component into the n.m.r. spectrometer to determine its structure

Instrumentation

E.J.Bourn
G.Stanley

Equipment designed and/or built during the year included a g.c. oven with reduced volume to improve the temperature gradient when used with glass and fused silica columns, and an introducer valve in which the carrier gas is 'O' ring sealed to the sample tube probe for more efficient transfer of sample. The following apparatus is now being built: an external temperature-control module featuring an introducer, a freeze-on port, a detector and an outlet-splitter and a new system for on-column transfer, utilizing a stainless steel jacket cooled by liquid nitrogen. A g.c. was also rebuilt to facilitate the use of high-resolution glass capillary columns for the sensory analysis of tomato volatiles.

A Milton Roy CI-10 integrator was interfaced to the high-performance liquid chromatograph.

Olfaction, taste and sensory evaluation

Psychophysical and physiological studies of the perception of odour mixtures

G.A.Bell
R.Gibson
D.G.Laing
J.D.Mellor
H.H.N.Panhuber
A.Spinelli

A multidisciplinary study of the perception of odour mixtures is being undertaken to determine the contribution of each odour component of a food to its aroma and acceptance. Human psychophysical experiments with binary mixtures of odorants indicated that the subjective intensity and chemical polarity of each odorant determines which will predominate in a mixture. Uptake of 2-deoxyglucose by rat brain cells was measured during presentation of odour mixtures and single odorants. The results showed that mixture processing takes place in the receptor epithelium in the nose and/or in the first connective structures that the receptors make with the brain. Odour responsive cells in the rat's olfactory bulb were also identified after rearing young rats for several months in an environment containing a single odorant.

Work aimed at improving the resolution of the 2-deoxyglucose technique led to invention of a new device for freeze-drying biological tissue and the development of a new technique for ultra-rapid freeze-fixation of tissue. Collaborative projects included a study of ultra-structural changes in brain tissue after sensory stimulation (with the University of Western Australia, Department of Anatomy) and the setting up of a research program in the CSIRO Division of Entomology using the 2-deoxyglucose technique to study insect pheromones.

Development of a simple clinical test of olfaction

D.G.Laing
G.A.Nicholson[6]
M.J.Vickery

A simple clinical test for olfactory deficiency is urgently needed to study its causes, identify affected persons, and to assess its effects on their diet, livelihood and social behaviour.

Recent advances in microsphere technology (encapsulating odorants into 'scratch-and-sniff' strips) offer a means of overcoming the difficulties associated with carrying odorants in bottles and allow the presentation of large numbers of odours in a convenient form. Accordingly, in conjunction with 3M Aust Pty Ltd, 122 odorous strips were assessed and 44 strips were found to be suitable for future trials with large community panels.

Computer-assisted measurement of the areas of the mitral cells of the olfactory bulbs of rats exposed to odours

Context effects in sensory evaluation

R.L.McBride

An artificial orange drink was presented for sensory evaluation in three overlapping concentration ranges, one range per sitting. The mean rating for a given concentration varied with the concentration range in which it was presented. For example, a concentration of 13.5% w/v was considered 'too strong' when presented in a low concentration range, but 'not strong enough' when presented in a high range. This result confirms and extends earlier work on a milk drink.

Integration psychophysics

N.H.Anderson[9]
R.L.McBride

The perception of food involves integration of many sensations, commonly from several sensory modalities, e.g. vision, taste, olfaction. To better understand the nature of this integration process, the methods of information integration theory were applied to the chemical senses. This focuses directly on the study of stimulus mixtures, which are often not amenable to traditional psychophysical analysis; moreover, it can handle those subjective properties for which there is no simple physical correlate, e.g. acceptability. Preliminary analysis of data from several integration tasks, such as the perception of taste mixtures, suggests that the integration process might follow a simple algebraic pattern.

Quality improvement

Adsorptive processes applied to citrus juices

R.L.Johnson
J.M.Myers

Adsorptive resins can be used to remove undesirable components of citrus juices. A study on the effects of resin on quality and authenticity indicators for citrus juices was initiated. One resin, which was very effective for removing titratable acids from citrus juices, and another resin, an effective debittering adsorbent, had no measurable effects on the sucrose, glucose, fructose and carotenoid contents, nor on the formol indices of treated juices. Both resins caused small but irreproducible losses of ascorbic acid and distillable oils; these losses were never more than 10% and were probably due to non-adsorptive processes such as oxidation. Whilst the deacidifying resin was effective in removing some bitter principles along with the acid, the debittering resin had a negligible effect on the titratable acid contents of treated juices.

Authentication of fruit juices

B.V.Chandler

In a collaborative program with the Trade Practices Commission and the Australian Government Analytical Laboratory, a procedure was devised for the authentication of commercial Australian orange juices. It was based on recent European studies which established chemical criteria for authentication by reference to analytical data for authentic juices representative of those in common world trade.

Analysis of food amines

D.Gallimore
D.L.Ingles

Studies on the physiologically active amines in foods were terminated with the publication of two papers on procedures for their analysis.

Browning in raw sugar

D.Gallimore
D.L.Ingles

A new procedure was developed for the isolation of acidic melanoidins produced by sugar-amine interactions, based on the adsorption of the melanoidin on strong base ion exchange resins and its subsequent displacement by acid to give a product uncontaminated by starting materials. The procedure could be adapted to production of the melanoidin on the preparative scale.

FOOD SAFETY AND NUTRITIONAL QUALITY

The microbiological safety of food depends on the control of food poisoning and spoilage microorganisms by treatments and conditions that kill them or prevent their growth during production, handling, processing, storage, marketing, and treatment in the home. Nutritional quality is affected by many of these steps and research is necessary to optimize conditions so that loss of desirable nutrients is kept to a minimum and the formation of deleterious substances is prevented.

The research in these two main areas is as follows:

- Microbial status and safety of food. Ecological and physiological factors affecting the microbial contamination of food and its environment during production, processing and storage are being explored. The ability of microbes to

survive, grow and produce toxins in foods is being defined, and the mechanisms of their resistance and the action of their toxins are being investigated. Many food components and additives affect the billions of microbes in the intestinal tract and their metabolism and the effects of these food substances and the microbial metabolites on the health and nutritional state of the host are being studied.

- Nutritional status and quality of food. The content and balance of the many chemical constituents of food and the complex interactions of these determine the final organoleptic quality and nutrient content of food at consumption. Research is concerned with the desirable and undesirable changes that occur in constituents during production, processing and handling, in particular the availability of essential nutrients. Fat metabolism and the control of excess fat deposition in animals is also under study as well as the effect of some food components on the intestinal absorption and excretion of other components.

MICROBIAL STATUS AND SAFETY OF FOOD

Food bacteriology

Enumeration of *Vibrio parahaemolyticus*

G.R.Davey[10]
M.J.Eyles
H.M.Wane

V.parahaemolyticus is often present in uncooked seafoods in concentrations which would permit the use of a plate count rather than a more cumbersome most probable number (MPN) method for its enumeration. A plate count, with thiosulphate citrate bile-salts agar as the plating medium, was compared with the MPN method, using alkaline peptone water as the enrichment medium, for enumeration of *V.parahaemolyticus* in 34 oyster samples. The MPN method gave significantly higher counts than the plate count. An associated survey of 30 market samples of oysters showed that *V.parahaemolyticus* counts may be higher than previous studies have suggested. *V.parahaemolyticus* counts in unopened oysters collected at the wholesale level had a median 1.1 x 10^3/g with a maximum of 2.3 x 10^4/g while counts in refrigerated opened oysters collected from retailers had a median 90/g with a maximum of 1.1 x 10^3/g. Identification procedures for *V.parahaemolyticus* were also investigated.

Microbiology of oysters

G.R.Davey[10]
M.J.Eyles
H.M.Wane

Shellstock of the Sydney rock oyster, *Crassostrea commercialis*, is frequently handled, transported and stored at ambient temperature. Storage experiments showed that this practice does not lead to growth of *V.parahaemolyticus* to hazardous levels in *C.commercialis* if the oysters are protected from extremes of temperature. During storage of naturally contaminated live oysters at 15° and 30°C for up to one week, counts did not become dangerously high. However, *V.parahaemolyticus* could grow to potentially hazardous levels (approaching or exceeding 10^6/g) during continuous or intermittent storage at 37°C for a few days. Counts of the indicator organism, *Escherichia coli*, did not change substantially during storage of oysters at 15° or 30°C.

Storage trials using oysters on the half shell showed that once Sydney rock oysters are opened, and thus killed, they provide a more suitable environment for growth of *V.parahaemolyticus*, which grew in opened oysters at 15°, 30° and 37°C, and at each temperature grew considerably more readily than in unopened oysters. These results contrast with studies using other species of oyster, which suggested that *V.parahaemolyticus* was inhibited by other bacteria present in opened oysters. The results show that opened Sydney rock oysters must be handled with the same precautions against temperature abuse as any other potentially hazardous flesh food that is to be consumed without further cooking.

Purification plant for oysters

Mycology

Fungi and food spoilage

A.D.Hocking
J.I.Pitt

'Fungi and Food Spoilage', a manual on food-borne fungi for the food microbiologist, is nearing completion and will contain keys to, and descriptions of, the 200 most commonly occurring fungal species in foods. Some spoilage yeasts are included.

Physiology of xerophilic fungi

A.D.Hocking
J.I.Pitt
D.Svoronos

Xerophilic and non-xerophilic fungi accumulate glycerol in response to lowered water activity, but the dynamics of the accumulation patterns are different. These differences may be partially explained by differences in membrane composition which alter the plasma membrane's permeability to small molecules such as glycerol. The effects of water activity and culture age on the total lipid composition of two xerophilic fungi, *Penicillium janczewskii* and *Wallemia sebi* and one non-xerophilic species, *Penicillium digitatum*, are being investigated. The membranes of *P.digitatum* have a higher degree of unsaturation than those of two xerophilic species, which could render them more permeable to glycerol.

Spoilage in Indonesian dried fish

A.Anggawati[11]
E.Gorczyca[12]
A.D.Hocking
J.I.Pitt
N.F.Tobin
L.C.Tuffs
K.A.Wheeler

Under an ACIAR grant, over 50 samples of Indonesian dried fish were examined. Fungi were isolated by dilution plating, direct isolation and a new effective technique, press plating. New media were developed, suitable for fastidious salt-tolerant fungi. Approximately 300 isolates from 60 fungal species were identified. The most important cause of spoilage was confirmed to be a new *Polypaecilum* species, now reported in the literature as *Polypaecilum pisce*. Other significant spoilage fungi were *Eurotium rubrum*, *Aspergillus wentii*, *Aspergillus penicilloides* and *Scopulariopsis halophilica*, now renamed *Basipetospora halophila*. Some work on the water relations of these fungi was carried out.

Scanning electron micrograph of *Aspergillus oryzae* (x4000)

Reports from overseas of possible aflatoxin contamination of dried fish prompted further study of fish from which *Aspergillus flavus* had been isolated. It was concluded that *A.*

flavus was present only at very low levels, as a superficial contaminant, and that toxin production was very unlikely. Aflatoxin assays on fish from which *A.flavus* had been isolated were negative.

Aflatoxins in Australian peanuts

A.D.Hocking
A.M.Irwin
J.K.Miflin
J.I.Pitt
N.F.Tobin

Results from the 1984 harvest season in Kingaroy, Qld, showed that peanut flowers and pegs can be invaded by *A.flavus*, but that such invasion does not necessarily lead to invasion of the developing peanut.

Flower and peg invasion therefore does not appear to be a useful monitoring system for possible aflatoxin in dried nuts. Invasion of the peanut usually occurred during the later stages of development under the influence of climatic factors and *A.flavus* levels in the soil. On the farms sampled in 1984, pod splitting and insect damage were very low, so invasion was almost always *via* the intact shell. Attempts to predict aflatoxin after harvest from the extent of invasion of *A.flavus* before harvest were encouraging but inconclusive, due to sampling variability. These studies are continuing during the 1985 season.

Mycotoxins

J.I.Pitt
N.F.Tobin

Attempts to isolate toxic compounds from sago rendered toxic by the growth of the mould *Gliocladium virens* continued. Organic solvents which will extract most known mycotoxins were tried unsuccessfully. The toxic component has apparently not been extracted but destroyed *in situ*. However, it appears to be unaffected by boiling water, and a combination of polar solvents may prove to be effective.

Various commodities from industry sources were examined for the presence of a wide range of mycotoxins, usually with negative results.

Mycotoxin data centre

P.S.Casey
J.I.Pitt

The Australian Mycotoxin Data Centre Newsletter completed its first volume of 10 issues. NH & MRC funding was secured for a further three years.

Gut microflora

Diet-related effects

R.F.Adams
P.L.Clements
J.J.Miller[13]
K.E.Murray
H.Podhaiski

Studies in rats showed that the type and quantity of ingested dietary fibre influenced the levels, in the caecal contents and faeces, of a wide range of microbial metabolites and enzymes. Scanning electron microscope studies of the gut surface confirmed an earlier finding that wheat bran was associated with extensive loss of enterocytes from the tips of the ileal villi.

Artificial gut

R.F.Adams
R.Kelly
K.E.Murray

A continuous culture of human faecal microflora was used to study the effect of individual food components, pH and Eh on the metabolic activity and composition of the microflora. At pH 6.6, lactose feeding was associated with a change in the phenol/*p*-cresol ratio of from 0.4 to 2.4. Lactose promoted lactobacilli and facultative anaerobes, and increased volatile fatty acid production. At pH 5.5 to 5.0, production of phenols decreased as the pH dropped.

Rapid methodology

R.F.Adams
M.J.Eyles
K.E.Murray

A study was initiated to evaluate the use of bioluminescence for the detection and measurement of microbial ATP for monitoring microbial contamination of foods. The profiling of amines present in spent cultures of *Clostridium botulinum* isolates continued. A unique amine profile was obtained for each of six *C.botulinum* types tested.

Preservatives

Mechanism of resistance in yeasts

P.L.Clements
A.D.Warth

The physiology of a number of species of yeast differing in their resistance to preservatives, is being compared in order to understand the mechanisms by which resistant species tolerate preservative, and to elucidate the effects of preservative on yeasts.

The system which transports the anion of the preservative previously found in *Zygosaccharomyces bailii* was present in nearly all the other species examined. By this system yeasts can maintain low intracellular levels of preservative despite the pH difference between the cytoplasm and the acid medium. However, energy is required to maintain intracellular pH by expelling the protons released by dissociation of the undissociated form of the preservative which continuously permeates the cell.

Uptake of preservative was too rapid for direct measurement, but an indication of net flow into the cell can be obtained from the increase in energy used by the cell. Chemostat studies showed that, in all species, benzoic acid stimulated fermentation and at high concentrations reduced the rate of cell production. The resistant species showed relatively small increases in fermentation rate, suggesting that they may be less permeable to preservative.

Bacterial toxins

Clostridium perfringens enterotoxin

J.Dennison[6]
J.A.Lindsay

The histological effects of *C.perfringens* enterotoxin on the small intestine were studied in the mouse and rabbit systems.

The ileum region of the gut was the most susceptible to the action of enterotoxin. After 15 minutes, morphological damage occurred with the villus epithelium showing desquamation. Longer incubation or increased enterotoxin levels resulted in gross damage where various amounts of villus epithelium and lamina propria were destroyed. Total loss of the lamina propria occurred mainly in younger animals and is probably associated with the highly sensitive nature of the developing gut.

Toxin receptors

J.B.Davenport
J.A.Lindsay

The receptor molecule to the *C.perfringens* 8-6 enterotoxin, isolated from the brush border membranes of rabbit small intestine, was purified and partially characterized.

Isolation of the enterotoxin receptor was found to be calcium- and heat-dependent. The receptor is both water- and alcohol-soluble although high concentrations of ethanol may precipitate the molecule without denaturation.

The receptor was found to be a three-subunit molecule of very high molecular weight. Only one of the receptor sub-

units is bound to the active hydrophilic subunit of the enterotoxin.

The second soluble molecule which enhances the *in vivo* action of the enterotoxin was found not to be the receptor molecule. Characterization of this molecule is continuing.

Spores

Spore heat resistance and the role of nucleic acids

J.A.Lindsay
W.G.Murrell

In vivo manipulation of spore nucleic acid content and type and the calcium and DPA levels was found to alter spore heat resistance. Several structural parameters, which were directly relatable to the increase in heat resistance, were observed to change. These changes included reduction in the size of the protoplast and reduction in protoplast water content.

Spore density/ water content

T.Beaman[14]
P.Gerhardt[14]
J.A.Lindsay

Spore protoplast water contents determined by buoyant density sedimentation correlated inversely with protoplast water contents of diverse types of lipozyme-sensitive dormant bacterial spores. The correlation equation provided a precise method of obtaining the water contents of other spore types when only small impure samples were available.

Thermophily

A.Lepelaar[15]
J.A.Lindsay

Chemical analysis of spores from genetically produced *Bacillus subtilis* (HTG) strains revealed that the transformants had very similar characteristics to those of the thermophilic parent. This was particularly true with respect to the calcium ion and DPA contents. Electron microscope studies revealed a reduction in protoplast size in the HTG transformants which was directly related to the reduction in water content of the spore and the concomitant increase in spore density.

How these modifications in structure and composition are genetically controlled is being examined.

Nuclear magnetic resonance (n.m.r.)

B.A.Cornell
J.A.Lindsay
W.G.Murrell
F.Separovic

A more detailed study of the interaction of various substances with DNA was made using a Brucker CXP 300 n.m.r. spectrometer to follow high resolution and broad line resonances as a method of exploring the biophysical state of the spore protoplast.

The ^{31}P T_1 *v.* a_w curve for DNA/DPA was significantly different from that for DNA/CaDPA. Although both molecules affect the molecular motion of the DNA sugar phosphate backbone, the data suggest that DPA intercalates into DNA in a different manner from CaDPA.

NUTRITIONAL STATUS AND QUALITY OF FOODS

Fatty acids

Pasture toxicity

A.C.Fogerty
G.L.Ford
D.Svoronos
K.H.Walker[7]

Pure methyl crepenynate (methyl octadec-*cis*-9-en-12-ynoate) prepared from the seed oil of *Ixiolaena brevicompta* (Compositae), previously shown to be toxic to sheep, was fed to chicks in addition to a basal ration. It produced severe breakdown of muscle tissue, as indicated by pathological examination and by increased levels of creatine kinase and

aspartate amino transferase in the blood serum. Methyl eleostearate, linoleate, or linolenate, administered to chicks in the same way as methyl crepenynate, did not affect muscle tissue. The phosphatidyl ethanolamine (PE) fraction of muscle contained most of the muscle arachidonic acid, but the fatty acid composition of the PE of muscles from chicks that had received methyl crepenynate for ten days was very similar to that of control chicks. There was no evidence of inhibition of the biosynthesis of arachidonic acid from linoleic acid.

Isolation of fatty acids

G.L.Ford

Techniques were developed for the isolation of single pure fatty acids on a semi-preparative scale by high-performance liquid chromatography (h.p.l.c.). Crepenynic acid was obtained from *I.brevicompta* seed oil in greater than 98% purity by these methods. Eicosapentaenoic acid and docosahexaenoic acid may now be obtained from suitable marine oils at a purity exceeding 90%.

Zinc deficiency and essential fatty acids

I.E.Dreosti[16]
A.C.Fogerty
G.L.Ford
D.Svoronos
I.J.Tinsley[17]

The effect of zinc deficiency on essential fatty acid composition of various tissues was studied in rats subjected to eight weeks' zinc deprivation. In contrast to other studies, where shorter deprivation times were used, this study revealed significantly elevated levels of arachidonic acid in the fatty acids of the neutral lipids of the livers of the zinc-deficient rats.

Fatty acid composition of Australian fish

C.R.Beales
A.J.Evans
A.C.Fogerty
G.L.Ford
D.Svoronos

Diet is a major factor determining the fatty acid composition of fish lipids, and in particular the relative abundance of ω3 and ω6 fatty acids. This relationship is best studied in herbivorous fish where diets can be more satisfactorily characterized than for fish feeding at higher levels in the food web. Analyses of flesh from herbivorous fish indicated a wide range of fatty acid compositions for different species, reflecting the variation encountered in dietary material of plant origin.

Lipids from a collection of fish species obtained from local markets were examined as possible sources of fish oil for the preparation of purified ω3 fatty acids. Most of these species have a low lipid content and are unsuitable for oil extraction. Oil produced by fish processors and canneries is of suitable composition for this work and methods were developed for the small-scale preparation of fatty acids from this material.

Free fatty acids in Australian sultanas

A.C.Fogerty
P.J.Rutledge
D.Svoronos

It was shown that the apparent acidity of lipid extracts from dressed sultanas was not due to the dressing oil used and, moreover, that genuine fatty acids accounted for less than one-third of the acidity observed in the extracts. The nature of the other acidic components has not been determined.

Fatty acid composition of Australian breakfast cereals

C.R.Beales
R.L.Hood

Breakfast cereals are manufactured from whole grain, or from fabricated mixtures by puffing, shredding, flaking and toasting processes. Mueslis were high in lipid, whereas most breakfast cereals were low in lipid. The fatty acid composition of most breakfast cereals reflects the composition of the cereal grain. Cereals with added fat, usually coconut oil, have low polyunsaturated to saturated ratios.

Biotin

Biotin content of infant foods

C.R.Beales
R.L.Hood

The biotin content of various canned and bottled infant foods manufactured in Australia is being analysed.

Fat metabolism

Cattle

D.C.Beitz[18]
R.L.Hood

Potential metabolic inhibitors were used to confirm the pathway for the conversion of lactate to fatty acids in bovine adipose tissue. Although the inhibitors were absorbed poorly into adipocytes, depression of lipogenesis by sodium oxamate and hydroxycitrate indicate that conversion of lactate to fatty acids occurs by way of the citrate cleavage pathway.

Calves

R.L.Hood
J.C.O'Kelly[19]
R.M.Seebeck[19]

Hereford and Brahman x Hereford calves suckling Hereford dams were used to determine if there were breed differences in adipose tissue composition in calves at weaning. The weights of triacylglycerols and cholesterol contained in fat depots at the same body weight were higher in Hereford than in crossbred calves. There were no breed differences in adipocyte volumes. The greater mass of adipose tissue in the Hereford breed was accounted for by an increased total number of adipocytes.

Dietary saponins and plasma cholesterol

S.Kozuharov
D.G.Oakenfull
R.W.Sleigh
G.S.Sidhu

A rat feeding trial showed that purified chickpea saponins and navy beans ('baked beans') produced significant lowering of plasma cholesterol and increased faecal excretion of bile acids and neutral sterols. They also increased the rate of cholesterol synthesis by the liver. A major cause of these effects was identified as a physical interaction of saponins with bile acids within the small intestine. Faecal excretion of bile acids is thereby increased, providing an indirect route for elimination of cholesterol.

Saponins may also inhibit absorption of other nutrients with significant nutritional consequences if consumption of foods rich in saponins were to increase.

The chemical structure of the saponin was all-important in determining its effect on absorption as studied *in vivo* using perfused loops of small intestine. Saponins with carboxylic acid groups (from *Saponaria officinalis* and *Quillaia saponaria*) inhibited absorption of glucose and the two amino-acids L-leucine and L-lysine; a neutral saponin (from soya) had no significant effect. Model studies *in vitro* of diffusion through cellulose membranes showed that slow absorption of glucose and amino-acids resulted from molecular interactions between these nutrients and mixed micelles of saponins and bile acids. The structure of these mixed micelles was studied by electron microscopy with negative staining. Saponins with carboxylic acid groups form helical structures with the capacity to occlude small molecules such as amino-acids and glucose.

Analysis of faecal bile acids by gas liquid chromatography (g.l.c.)

S.Kozuharov
G.S.Sidhu

A g.l.c. method using support-coated open tubular columns was developed for faecal bile acid analysis. Conditions were worked out for quantitative derivatization of bile acids. Methylation was achieved using 2,2-dimethoxypropane in methanol and acylation with pentafluoro-propionic anhydride. This method is being used for the analysis of faecal bile acids of rats fed cholesterol and various saponins in the diet.

FOOD STRUCTURE

The Food Structure Group is studying the intramolecular and intermolecular forces that control the structure of foods, and the relationship between the physical and functional properties of food and their structure.

The major components responsible for the structural integrity of most foods, other than fruits and vegetables, are lipids, proteins and water, so efforts are being concentrated on systems involving only these three components. The principal proteins chosen for study are those found in eggs. Their interactions are being used as models for other protein-lipid interactions.

Proteins and lipids in water can aggregate spontaneously to form colloids or emulsions and these have a considerable effect on the texture and stability of food.

Some lipids, when suspended by themselves in water, can form bilayer structures if some mechanical energy is supplied. These bilayers closely resemble the membranes that constitute the outer walls of the cells in food. Consequently, these bilayer membranes are much studied in attempts to understand the role of membranes in controlling the properties of foods.

Proteins

The protein analyzing laboratory

J.F.Back
R.W.Burley
R.W.Sleigh

Instruments have been installed that will be part of a protein analyzing laboratory. These include a gas-phase amino-acid sequencer with h.p.l.c. for the identification of derivatives, an amino-acid analyzer and h.p.l.c. for the separation of proteins and peptides. These instruments will be available to other Divisions in the Institute of Animal and Food Sciences.

After installation and testing with known proteins, the first new protein to be examined on the sequencer was a protein from the vitelline membrane of hen's eggs (VMOI) first isolated at the Division. About one-quarter of the sequence was determined. According to predictive methods, this part of the protein has a very low helix-forming potential. The vitelline membrane was also used to test the resolving power of the h.p.l.c. system used for protein separations. Two minor proteins, provisionally termed 'VMOII' and 'VMOIII', were isolated.

Determining the sequence of amino-acids in the peptide chain of a protein

Protein-lipid interactions

R.W.Burley

As part of a study of lipid-protein interactions in hen's eggs, a rapid electrophoretic method was developed for identifying proteins with a high affinity for lipid. The method was used to identify three proteins in hen's egg yolk with an especially high affinity for lecithin.

Portomicrons of laying hens

J.F.Back
R.W.Burley
F.S.Shenstone

Portomicrons, the avian equivalent of mammalian chylomicrons, have an essential role in the transport and metabolism of lipids. It has previously been found at the Division that the portomicrons of laying hens contain a protein of low molecular weight with the same electrophoretic mobility as the yolk apoprotein, apovitellenin I. A preliminary determination of the N-terminal amino-acid sequence of this protein confirmed that parts of its sequence are the same as that of apovitellenin I.

Egg allergens

D.Barnett
R.W.Burley
C.Delaney[3]
C.Elliott[3]
M.Howden[3]

Following the observation that the low-density lipoprotein of egg yolk contains allergenic apoproteins, the allergenicity of purified apovitellenin I was tested by RAST and its allergenic properties confirmed. The allergenicity of the enzymically-produced fragments of ovalbumin from hen's egg white were investigated.

Biosynthesis of egg yolk

C.R.Beales
R.W.Burley
A.J.Evans

Previous studies at the Division, in which the apoprotein patterns of egg yolk and blood lipoproteins of hens were compared, led to the suggestion that major apoproteins of yolk low-density lipoprotein were derived by enzymic splitting from apo B, the principal apoprotein in plasma very-low-density lipoprotein (VLDL). By using tritiated VLDL and measuring the specific activity and distribution of activity

in yolk lipoprotein apoproteins, it was established that complete splitting of apo B into smaller fragments occurs in the ovarian follicle during yolk formation. The nature of the enzyme responsible is under investigation.

Proteins from eggs of the estuarine crocodile

J.F.Back
R.W.Burley
G.C.Grigg[6]
J.Wellington[6]

As part of the work supported by the CSIRO/University of Sydney Collaborative Research Fund, a study is being made of proteins from eggs of the crocodile (*Crocodylus porosus*). This work has implications that are practical, because crocodile farming is under way in the Northern Territory, and theoretical, because of the possible close evolutionary relationship between crocodiles and birds. Proteins of the albumen, vitelline membrane, and yolk are being compared with those of hen's eggs. Large differences have been found. Crocodile's eggs have a lower proportion of protein and the lipoprotein pattern is different.

Colloids

Stabilizing forces in colloidal suspensions

L.R.Fisher
R.A.Gamble
E.E.Mitchell
N.S.Parker

The measurement of the rate of drainage of liquid from between approaching emulsion droplets and the forces and equilibrium distances between droplets continues. In parallel with these fundamental measurements, a new project is under way to investigate the adsorption of food emulsion stabilizers at the surface of vegetable oil droplets in water and the way in which the adsorption behaviour differs from that at the more widely studied hydrocarbon oil/water interface. Special attention is being paid to the behaviour of proteins, the aim being to determine the emulsion stabilizing properties of proteins from cheap sources.

Cell adhesion

R.F.Adams
L.R.Fisher
G.W.Francis
R.A.Gamble
D.Gingell[20]
K.Williams[3]
E.Evans[21]

Following the successful use of the apparatus for measuring interactions between emulsion droplets, a miniaturized version is being developed which will fit on a microscope stage and which will be capable of measuring the forces between living cells. Cell adhesion is fundamental to many aspects of the food industry, ranging from the control of bacterial adhesion to food or food handling equipment to maintaining the integrity of foodstuffs during treatment. The apparatus will be used particularly to measure the effects of changes in environment on cell adhesion forces.

Food gels

D.G.Oakenfull
A.G.Scott

To understand (and hence predict and control) the properties of food gels it is necessary to know how gel-forming polymers are cross-linked. Information about the cross-linkages is being derived from measurements of shear modulus of very soft gels. As existing experimental methods were not suitable for some food gelling systems, the operating range of the Instron Universal Testing Machine was extended by use of an electronic microbalance. This apparatus was successfully applied to the study of carrageenan gels which appear to have very complex cross-linkages containing segments from many polymer molecules.

Kinetic studies can also provide information about the mechanism of gelation, particularly the number of segments of polymer molecules which associate and the nature of the intermolecular forces involved. A simple but effective method has been devised for measuring rates of gelation.

Gelation of gelatin and carrageenan simply decreases in rate with increasing temperature but high methoxyl pectins behave in a much more complex manner. From 0° to 30°C their rate of gelation increases, decreasing only at higher temperatures. The dependence of gelation rate on concentration again indicates the extreme complexity of the cross-linkages in carrageenan gels. With high methoxyl pectins and gelatin, the cross-linkages are formed from two and three segments from the polymer chains, respectively, confirming results previously obtained from measurements of shear modulus.

Membranes

Protein mobility and membrane function

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A.D.Albert[22]
R.Hiller[3]
A.Post[3]
J.K.Raison
R.N.Robertson[6]
F.Separovic
R.Smith[23]
L.Weir
P.Westerman[24]
P.L.Yeagle[22]

All plants, animals and bacteria depend for their function and physical properties on the behaviour of one or more biological membranes. The ultimate goal of this work is to relate these properties to the molecular order and dynamics of the lipids and proteins which comprise the elements of natural membranes. A major question is the relationship which exists between the physical state of membrane lipids and the order and dynamics of the membrane protein. Solid state n.m.r. is being used to study a variety of situations in which these interactions are apparent. A similar approach is being followed to discover the changes that occur in motion of the transmembrane transport protein bacteriorhodopsin when it is activated by light. Extensive use is being made of compounds which have been synthesized with carbon-13 and deuterium-2 labels at specific sites, to identify the motion undergone by specific segments within both the lipids and proteins.

A closely related project is under way on the role of the quinones, ubiquinone and plastoquinone, in the redox-coupled transport chain of mitochondria and chloroplasts.

In all of this work, parallel studies are performed using both a complement of physical techniques such as solid state n.m.r., X-ray diffraction and differential scanning calorimetry together with an equally diverse series of assays of the biological activity of the membranes.

Conformation and dynamics of carbonyls in proteins and lipids

B.A.Cornell
V.Braach-Maksvytis[6]
F.Separovic

The location at which many carbonyl groups occur within the backbone of both phospholipids and proteins, provides a valuable insight into the overall reorientation undergone by such molecules in membranes. Solid state carbon-13 n.m.r. has been used to determine the carbon chemical shielding tensor in this region so detailed models can now be provided of the conformation and dynamics of one important class of molecular sites involving carbonyl groups.

A new direction for this work has been to apply these techniques to study the interaction of odorant molecules to membrane bound receptors.

Modelling of membrane structure and dynamics

B.A.Cornell
B.H.Kennett
J.Middlehurst
N.S.Parker
F.Separovic

The balance of forces that results in the formation of lipid bilayer membranes appears to be predominantly thermodynamic in origin and does not depend to any obvious extent on the presence of localized intermolecular covalent bonding. A major contribution to the free energy of these systems is the steric constraints imposed by the molecular geometry. The only practical manner of modelling the contribution of these geometrical factors to the formation and structure of

membranes is by computer simulation. Extensive use of both Monte Carlo and molecular dynamic simulation of two-dimensional arrays of particles of different shapes is providing a basis for interpreting the results of the experimental data. It is a starting point for understanding the more detailed force laws governing the interaction of membrane components.

PLANT PHYSIOLOGY

The aims of the Plant Physiology Group are to improve the postharvest handling, transport and storage of fresh fruits and vegetables and to develop an understanding of the fundamental principles involved in postharvest physiology and biochemistry. Solutions to problems of immediate and practical concern to the fresh fruit and vegetable industry are being sought, and longer-term programs are continuing with the aim of providing fundamental knowledge relevant to the more intractable problems of the industry. There are three major, interactive subprograms:

- Postharvest fruit and vegetable storage and handling
- Temperature stress on plants
- Fruit ripening and senescence.

Postharvest fruit and vegetable storage and handling

Research is concerned mainly with solving postharvest problems in the storage and handling of some of the major fruit crops in Australia, developing new strategies for storage of fruits and vegetables and developing methods for the handling and storage of new or previously under-utilized tropical and other fruits.

The subprogram on postharvest storage and handling is supported by the other two subprograms which aim to determine how to overcome the problems of temperature stress in plants, as during low temperature storage, and of regulating fruit ripening and senescence.

Quality of tomatoes

D.J.Best[25]
D.G.Laing
R.L.McBride
W.B.McGlasson
S.K.Meldrum
V.Q.Nguyen[7]

The aim is to improve the quality and flavour of fresh tomatoes available to Australian consumers. Fruit from field trials of new determinate cultivars were evaluated for flavour and other postharvest quality attributes. Emphasis was placed on the selection of cultivars suited to a production system on plastic mulch in the drier inland areas of south-eastern Australia. Ripening temperatures for the leading commercial cultivars were evaluated. Ideal ripening as judged by the rate of softening and colour development took place at 15°-20°C. Fruit tended to soften excessively at 22°C although colour development was only slightly faster than at 20°C. Tomatoes which were ripened at 13°C retained firmness better than those ripened at higher temperatures, but the colour was more pink.

Preliminary studies were conducted using a sensory panel to assess the relative contributions of taste and aroma to flavour in several cultivars chosen for their wide range of differences in soluble solids and flavour. Fruits of the mutants *rin* and *nor* contain concentrations of sugars and acids similar to those of Rutgers but have greatly reduced levels of aroma compounds.

Kiwifruit

K.J.Scott[7]
S.A.Spraggon

The kiwifruit industry in New Zealand and in most other countries is based on the Hayward cultivar. In Australia this cultivar was not available and many plantings are of cultivars considered to have a poor storage life compared with the cultivar Hayward. However, some of these seem more suitable for cultivation in northern NSW and Queensland than Hayward. A study confirmed that these cultivars did not store as well as Hayward under conventional conditions but a modified atmosphere treatment including ethylene removal markedly increased the storage life.

Taste testing different cultivars of kiwifruit from three different regions to determine optimum time for harvest

Doubts have been raised concerning the suitability of the New Zealand maturity test (6.25% of soluble solids) for use in the warmer parts of Australia. Studies are in progress to determine whether other indices of fruit maturity are suitable.

Rotting of guava, lychee and custard apple

B.I.Brown[26]
K.J.Scott[7]

In a collaborative project with Queensland Department of Primary Industries it was found that dipping the fruit in the fungicide Prochloraz after harvest considerably reduced rotting.

Shelf-life of lychee

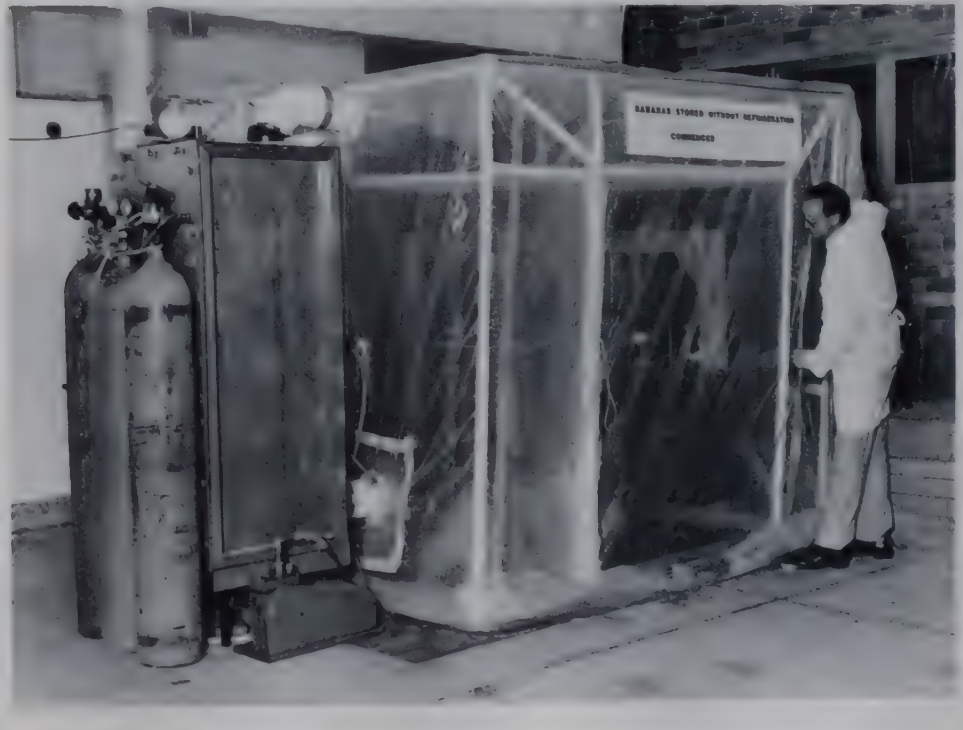
P.Y.Huang[27]
K.J.Scott[7]

Earlier studies showed that, in the absence of refrigeration, the use of hot benomyl to control rotting and packaging in plastic punnets with a plastic overwrap to prevent browning, increased the shelf-life of lychees considerably. In a collaborative experiment with the South China Institute of Botany, this result was confirmed with other cultivars.

Controlled atmosphere storage of bananas

K.J.Scott[7]
A.J.Shorter

Studies are in progress to determine whether controlled atmosphere storage at ambient temperatures can be used to overcome gluts of bananas on the Australian market. A plastic tent system incorporating an ethylene scrubber is being used to develop the controlled atmospheres.



Long-term storage trials of bananas at ambient temperatures in atmospheres of low concentrations of ethylene

Cooling horticultural produce

N.L.Wade[7]
P.Watt

A formula was derived which describes the refrigeration capacity required to cool fruit and vegetables to any desired temperature within a specified time. Its use requires the experimental determination of the relationship between air flow-rate and seven-eighths cooling time, and the value of the lag factor j in the exponential cooling equation. Both unknowns can be found by measuring the temperature history of produce cooling under controlled conditions of temperature and air flow. A prototype low-velocity wind tunnel was constructed and is being used to collect data for use in refrigeration capacity calculations.

Mango flavour studies

G.R.Chaplin
S.H.Satyan

The chromatographic patterns of headspace volatiles collected from fruit of new mango cultivars varied between cultivars both quantitatively and qualitatively. One particular peak was dominant in Florida cultivars and significant in the Australian cultivar Kensington. However, this peak was only minor, or absent, in several Indian cultivars tested. Continuation of these studies should improve the understanding of the bases of flavour quality in mango fruit.

Mango and other tropical fruit (ACIAR)

G.R.Chaplin
S.P.Cole
D.Graham
P.F.Lam[28]

Studies began on the effect of low postharvest temperatures on the development of chilling injury in mangoes. The visual symptoms of chilling injury were characterized by the development of bronze-coloured lesions on the skin. The symptoms did not usually develop until the fruit were removed from the low temperatures. No external chilling injury symptoms occurred in fruit stored at 10°C. However, fruit stored for 20 days or more at 10°C were adversely affected by fungal rots, which appeared to be induced by the cool temperature.

Postharvest physiology, pathology and handling of bananas (ACIAR)

D.Graham
E.E.Kavanagh
N.L.Wade[7]

The aim is to develop improved handling technologies, and special attention is being given to the deleterious effects that ethylene has on banana shelf-life. Studies were conducted on the absorption of ethylene by potassium permanganate applied to inert carriers. The surface properties of the carrier material are critical in determining how much ethylene is absorbed. The physicochemical characteristics which govern the kinetics of ethylene absorption are being determined.

Leakage from ripening banana fruits (ACIAR)

E.E.Kavanagh
H.Nair[29]
N.L.Wade[7]

Banana fruit pulp tissue becomes increasingly leaky to small ions and molecules as it ripens, and this phenomenon is closely related to the increase in soluble solids content and softness which determine ripe fruit quality. The causes of this leakage are being studied by measurement of electrolyte leakage into bathing solutions, the use of metabolic inhibitors, and fluorescence microscopy.

Transport and storage of fruit and vegetables in Papua New Guinea (PNG) (ACIAR)

G.Atkinson[30]
M.Forbes-Smith
D.Graham
S.C.Morris[7]
S.H.Satyan
K.J.Scott[7]
C.Warisaiho[30]

PNG imports a considerable proportion of its food requirements, including fresh vegetables and fruit. The aim is to assist in making the country more self-sufficient in fresh vegetables by developing a method of surface transport to replace the present costly air shipments within the country. International shipping containers are being used in trials in PNG to determine optimum conditions for shipment of mixed loads of produce. A successful trial shipment was made between the PNG Highlands and Bougainville. Other trials are in progress with a wider range of commodities.

The development of low cost methods for storing cooking bananas is also in progress. Initial studies concentrated on determining the postharvest physiological and chemical changes in these bananas from an Australian source. These data will be used to define the appropriate storage regime.

During harvesting and handling, Irish and sweet potatoes suffer physical damage which enables pathogens to invade the produce. Such invasion can be minimized if the potatoes can develop a natural, suberized, protective layer over the damaged areas, a process known as curing. The conditions for curing are different for each commodity. Studies defined

the conditions of temperature and humidity which will be used to develop a regime to enable transport of mixed loads in shipping containers in PNG.

Measuring the respiration of capsicums for the ACIAR PNG project

Temperature stress on plants

Tropical plants and their fruits are sensitive to chilling temperatures (from their freezing point to 15°C). Accordingly, a fundamental understanding of the causes, responses and amelioration of chilling injury is being sought with potential application through plant breeding and future genetic engineering.

A primary cause of thermal sensitivity results from the lipid composition of cell membranes, so an understanding of membrane behaviour is being sought. The effects of low temperature on enzymes and cell metabolism are being investigated to further understanding of a plant's response to chilling. The potential for transfer of genes for chilling tolerance is being determined and methods of screening for chilling and heat tolerance are being devised for use by plant breeders.

Molecular basis of the phase transition in cell membranes

G.R.Orr
J.K.Raison

The correlation between the temperature of the phase transition in the polar lipids of chloroplast membranes and the temperature below which chilling injury develops in chilling-sensitive plants is being investigated. For *Nerium oleander*, a plant which can acclimate to grow at high or low temperature, the phase transition shifts from -3°C to 7°C when growth temperature is increased from 20°C to 45°C. Thus these clones provide ideal material for studying the molecular

components responsible for the transition and its change during acclimation.

Phosphatidylglycerol (PG) from plants acclimated to 20°C show a phase transition at 19°C while for plants acclimated to 45°C the transition is at 27°C. The proportion of C16:0 fatty acid in PG increases from 27% to 41% while that of C16:0 plus C16:1 *trans* fatty acids increases from 53% to 58%. This indicates that the temperature of the phase transition and hence sensitivity to chilling is related to the amount of C16:0 rather than the amount of C16:0 plus C16:1 as previously suggested. Thus the sensitivity of plants to chilling might be altered by changing the amount of this lipid species.

Membrane phase transition and chilling injury

G.R.Orr
J.K.Raison

The involvement of mitochondrial membrane lipids in phase transitions and their relationship to chilling injury in plants was re-examined. Polar lipids were obtained from soybean seed as well as from mitochondria of hypocotyl tissue of soybean, mungbean and the fruit of cucumber and tomato and examined by differential scanning calorimetry. In all samples an exothermic phase transition could be detected at about 12°C to 15°C, depending on the species and from the heat of the transition to 0°C it was estimated that about 3% to 5% of the lipid was involved. The temperature of the transition correlated with the temperature below which injury develops in the respective tissue. The results thus support the hypothesis that the primary event initiating chilling injury is a disruption to the structure and function of cell membranes.

Role of PG in chilling sensitivity of plants

D.G.Bishop
J.R.Kenrick

The fatty acid composition of PG from leaves is being measured to establish whether the postulated role of this lipid in inducing chilling injury in plants is generally applicable, and whether analysis of PG fatty acids can be used as an index of chilling susceptibility. Some chilling-sensitive plants whose PG fatty acid composition would indicate that they are chilling resistant were identified and attempts are being made to determine whether such plants belong to specific botanical or biochemical groups.

Biosynthesis of chloroplast membrane lipids

D.G.Bishop
K.Kleppinger-Sparace[31]
J.B.Mudd[31]
S.A.Sparace[31]

The biosynthesis of chloroplast lipids, which have a potential role in chilling sensitivity of higher plants, was studied. While it is now evident that essentially all of the chloroplast PG is synthesized in that organelle, both chloroplast and endoplasmic reticulum contribute intermediates for the biosynthesis of sulphoquinovosyldiacylglycerol (SQDG). The relative contribution which each organelle makes to SQDG synthesis may differ widely in various plants. It was shown that isolated spinach chloroplasts could incorporate sulphate ion into SQDG at rates equivalent to that occurring in the leaf.

Cold sensitivity of phosphoenol-pyruvate (PEP) carboxylases in C3 plants

D.Graham
D.G.Hockley
B.D.Patterson

PEP carboxylase, a key regulatory enzyme of plant respiratory metabolism, is cold sensitive in lowland, tropical, chilling-sensitive C3 plants whereas chilling-resistant C3 plants have a cold resistant PEP carboxylase. This phenomenon was further characterized in chilling-sensitive and chilling-resistant plants by molecular weight determinations of the various forms of the enzyme and analysis of their pH-related properties.

Isolation of PEP carboxylases

D.Graham
D.G.Hockley
B.D.Patterson
J.-P.Simon[32]

A range of dye-ligands coupled to matrices were tested for their ability selectively to absorb PEP carboxylases from a range of C4 and C3 plants. The method shows promise as a technique for selective purification of PEP carboxylases although the desorption process seems more effective for the enzymes from C4 plants than for the C3 enzymes.

Detection of cold-sensitive plant proteins

D.Graham
D.G.Hockley
T.Matsuo[33]
B.D.Patterson

A number of plant proteins are known to be cold-sensitive at chilling temperatures above the normal freezing point of tissues. A polyacrylamide gel electrophoresis method was devised to determine the cold-sensitivity of proteins in extracts from plant tissues and is being applied to a range of chilling-sensitive and chilling-resistant plants to determine the extent to which their proteins are cold-sensitive.

1-Aminocyclopropane-1-carboxylic acid (ACC) as an indicator of chilling injury

Y.Z.Chen[27]
D.Graham
B.D.Patterson
L.A.Payne

It was shown that ethylene is evolved by the tissues of tropical plants after they are chilled, but the capacity to produce ethylene is easily destroyed by chilling injury. The immediate biochemical precursor of ethylene is ACC. This compound was found to accumulate in chilled tissue of various species at a rate which was related to their chilling sensitivity. Such determinations may be applicable to citrus fruits, for example, to assess their suitability for cold disinfestation against fruit fly.

Glutathione and chilling sensitivity

D.Graham
S.Koike[34]
B.D.Patterson

The level of reduced and oxidized glutathione may be relevant to the ability of plant tissues to resist chilling. The level of reduced glutathione varied in tomato seedlings between 200 nmole.g^{-1} in the middle of the night to 400 nmole.g^{-1} in the middle of the day. Seedlings chilled for 24 h from 4 h into the night retained their levels of reduced glutathione, but seedlings chilled from the beginning of the day did not. Diurnal variations in the level of glutathione may influence diurnal responses to chilling previously observed in this laboratory. Mature leaves of a chilling-sensitive species of passionfruit did not lose glutathione during chilling, however, so the relationship with chilling sensitivity may not be a universal one.

Chilling resistance from wild tomatoes

L.Mutton[7]
V.Q.Nguyen[7]
B.D.Patterson
L.A.Payne
M.B.Smith

The tissues of the highland ecotype of the wild tomato, *Lycopersicon hirsutum*, can survive a greater chilling stress than those of the domestic tomato. This characteristic is likely to be useful at the fruiting stage, but must be selected for at the seedling stage. An apparatus is being built to detect those seedlings which are able to continue characteristic diurnal leaf movements after a chilling stress. For the practical application of the chilling resistance derived from *L.hirsutum*, characteristics useful after harvest such as chilling resistance of the fruit, are being combined with those useful during plant development. Families of tomatoes incorporating parentage from the wild tomato species *L.hirsutum* were examined for chilling resistance at different stages in their life-cycle. For instance, fruit does not set in domestic cultivars when night temperatures are below 10°C and this appears to result from a specific effect of chilling on pollen development.

Chlorophyll fluorescence and stress injury

R.S.Nott
R.M.Smillie

Chlorophyll emits a red fluorescence when excited by white light. The rate of the rise of induced chlorophyll fluorescence (F_R) in living plant tissue was previously shown to be a rapid diagnostic tool for chilling and certain other stress injuries in crop plants. By comparing F_R with photosystem II activity, changes in F_R were related to stress-induced changes in photochemical activity. Following chilling injury to maize and heat injury to barley, the decrease in photosystem II activity was linearly related to log F_R. The same relationship was found during the early stages of photoinhibition and during ageing of isolated chloroplasts. It is concluded that the exponential decrease in F_R seen in chilling-sensitive plants during exposure to low temperatures is indicative of a linear decrease in photosystem II activity linked to oxygen evolution *in vivo*.

Low temperature enhanced photoinhibition at high light intensity

R.S.Nott
R.M.Smillie

Bright sunlight can cause irreversible damage (photoinhibition) to leaves of crop plants already stressed by low temperature or water deficit. Exposing maize and barley leaves to bright white light and 1°C resulted in decreases in induced and delayed chlorophyll fluorescence emissions, chlorophyll fluorescence yield at 77°K and quantum yield of photosystem II activity, which were consistent with damage to the active site of photosystem II. Changes in fluorescence excitation spectra indicated a preferential photodamage of carotenoids compared with chlorophyll. The time courses of the fluorescence changes were similar in maize and barley indicating that, at high light and low temperature, both chilling-sensitive and resistant plants are susceptible to photoinhibitory damage.

Photoinhibition at low light intensities and chilling temperatures

R.Hodgson[3]
J.K.Raison

Photosynthesis is inhibited by 80% in 5 h when leaves of chilling-sensitive plants are exposed to low light intensities at 4°C. No inhibition occurs with leaves of chilling-resistant plants under the same conditions. This chill-induced photoinhibition also occurs with leaves of *Nerium oleander* grown at 45°C but not in leaves of plants grown at 20°C. Thus, in this respect, oleander grown at 45°C exhibits a physiological response typical of a chilling-sensitive plant. This is consistent with previous observations that the phase transition for the chloroplast polar lipids of this plant is at 7°C while for oleander grown at 20°C it is at -3°C.

The inhibition of photosynthesis induced by low light and chilling was found to be dependent on the light. The cause of the inhibition is unclear. It is not due to the chilling alone. Nor is it due to a loss of chlorophyll or inhibition or disruption to the two primary photosystems. There is some evidence that it is related to the ordering of the membrane lipids and the details of this relationship are being investigated.

Carotenoids as antioxidants for plant membrane lipids

M.A.Brown
J.K.Raison

Reactive radicals, including singlet oxygen, are thought to be involved in the inhibition of photosynthesis by light. For chilling-sensitive plants, photoinhibition can be induced by light intensities less than those used to grow the plant, provided the temperature is below that of the phase transition in the membrane lipids. Carotenoids, associated with the chloroplast membranes, can act as scavengers of singlet oxygen and are reported to lower the phase transition

temperature of membrane polar lipids from algae. The ability of carotenoids to protect the membrane lipids of soybean lecithin liposomes from peroxidation, as well as the influence of carotenoids on the phase transition, was investigated. Carotenoids and thylakoid polar lipids were isolated from clones of *Nerium oleander* showing differing responses to chilling and tested for their ability to prevent lipid peroxidation induced by gamma radiation. It was concluded that if chill-induced photoinhibition is initiated by reactive radicals the supposition that carotenoids provide protection cannot be substantiated in isolated systems. In addition, carotenoids and neutral lipids do not appear to alter the phase transition of membrane polar lipids of higher plants.

Photoinhibition and flooding

R.S.Nott
R.M.Smillie

Photoinhibition could be a serious problem during flooding. The roots of bean plants were flooded and photosynthesis of leaf samples measured during several days of almost cloudless weather. Except for the first day of flooding, plants in full sunlight showed extreme wilting while plants exposed to one-quarter of full sunlight did not wilt. However, the light-saturated rate of photosynthesis decreased at similar rates in plants under either condition, as did subsequent losses of leaf chlorophyll. Only small decreases in quantum yield and no decrease in induced chlorophyll fluorescence at 77°K indicated that even though photosynthesis decreased markedly, little photoinhibition had occurred. It was concluded that the loss of photosynthesis in the leaves of flooded plants was due to accelerated senescence probably attributable to root damage and was not a consequence of photoinhibitory damage. In flooded plants exposed to full sunlight, reduction of the angle of the leaf surface incident to light by wilting appears to be an adequate mechanism for avoiding photoinhibition.

Chilling injury and water stress

R.S.Nott
R.M.Smillie

Water stress in leaves was shown to have a hardening-like effect in relation to chilling injury, increasing the chilling resistance of the leaves. Leaves of bean and maize were most sensitive to chilling at 0°C when fully turgid. At 100% R.H. there were no significant differences in the rate of chilling injury, as measured by chilling-induced changes in chlorophyll fluorescence, in chilled leaves still attached to the plant with the remainder of the plant kept at either 0°C or 20°C and in chilled detached leaves. However, attached leaves chilled at a lower R.H. were more chilling resistant. Water stress before chilling also increased chilling resistance, but the effects of a mild stress were reversed by rehydrating the leaves prior to chilling. Severe water stress resulted in reduced chilling injury even when the leaves were chilled at 100% R.H. As mild water stress can easily occur both in field-grown plants and in plants grown in containers, it is important to control the water status of plants both before and during chilling if meaningful results are to be obtained in experiments on chilling injury.

Effect of hypothermia on membrane permeability

A.Hulbert[35]
J.K.Raison

The differential effect of temperature on ionic pumps in membranes of warm-blooded and cold-blooded heterotherms was examined. Hepatocytes were isolated from liver tissue by perfusing with isotonic buffer containing ethylenediaminetetraacetic acid to chelate the calcium and abolish cellular

adhesion. This method produced cells better than 90% viable without damage to the ion pumps and in large yields. The plasma membranes of the hepatocytes showed a phase transition at 17°C and spin labelling studies indicated that the membrane lipids phase separate below this temperature. This change in the molecular ordering of the lipids may be sufficient to account for the loss of ionic gradients. However, a definitive explanation necessitates an examination of the thermal response of the ion pumps, which are integral components of the plasma membrane, which might be affected by the phase transition.

Membrane changes during hibernation in animals

R.C.Aloia[36]
M.Augee[13]
J.K.Raison

It had been shown that the temperature of the phase transition in polar lipids of liver mitochondria is lowered from 23°C to below 4°C as a prerequisite for hibernation. This response was confirmed in mitochondria from brown fat adipose tissue of golden-mantled ground squirrels (*Cittelus lateralis*) maintained in a colony at the Loma Linda Medical School in California, USA. The changes in transition temperature are not, however, induced by the lower ambient temperatures of the natural environment as winter approaches, since in the present experiments the colony was maintained in the laboratory at 22°-25°C. The results thus provide further support for the view that the change in the thermal response of the membrane lipids is a seasonal event linked to hormone activity.

Irradiation damage to cell membranes

J.Gebicki[3]
J.Guille[3]
J.K.Raison

Ionizing radiation can cause marked changes in the functional properties of erythrocyte membranes. These include increase in permeability to ions, osmotic fragility and autohaemolysis and it is generally believed that the irradiation causes changes to the physical properties of the membrane lipids. To test this hypothesis, polar lipids from human erythrocytes were irradiated from a ^{60}Co gamma source, up to doses of 100 Gy, and the effect on the peroxidation and fluidity of the membrane lipids investigated. Considerable peroxidation of lipid occurred, but no significant change in membrane lipid fluidity could be detected when the lipids were extracted from the membrane and fluidity was measured by spin labels intercalated with liposomes formed from the lipids. This method avoided the difficulties associated with measuring fluidity in membranes where the integral proteins can interact with spin labels. It was concluded that the changes in the functional properties of the erythrocyte induced by irradiation were most probably the result of alterations to the membrane proteins rather than to changes in the fluidity of the membrane lipids.

Fruit ripening and senescence

Research is designed to further understanding of the fundamental cellular processes controlling ripening in fruit and senescence in plant cells. The approach is that of molecular biology because of the potential for future genetic engineering to modify plant varieties to suit commercial requirements. The ripening of the tomato fruit is being studied because it is a major horticultural crop that is available year-round and can be grown under controlled conditions. This work is linked with tomato quality research in the post-harvest fruit and vegetable storage and handling subprogram.

Polygalacturonase enzymes in tomato fruit

C.J.Brady
J.A.Pearson
J.Speirs

During the ripening of tomato fruits, three forms of the pectin hydrolyzing enzyme, polygalacturonase, appear in the pericarp tissue. Beginning at the 'breaker' stage, an enzyme, termed PG1 and of apparent molecular weight (M_r) in excess of 100 000, appears and softening of the fruit begins. Two or three days later two smaller forms of the enzyme PG2A and PG2B, M_r 43 000 and 45 000 respectively, appear and these continue to accumulate for at least 10 days. PG1 has two subunits, both glycoproteins, but immunologically unrelated. The larger subunit is identical to PG2A in immunological properties, in size and charge, and in the peptides released by trypsin and chymotrypsin action. The smaller subunit is more acidic and contains more carbohydrate. PG1 has 16% neutral carbohydrate as mannose, xylose and fucose, and also contains glucosamine.

PG2A is separable from PG2B by molecular sieve chromatography and by affinity chromatography using Concanavalin A. PG2A contains 8% neutral carbohydrate as mannose, xylose and fucose, and about 3% glucosamine.

The three enzymes have endopolygalacturonase activity, but PG1 differs in being more active at low ionic strengths, and in being more firmly attached to cell wall substrates. These properties should favour its action in the normal tissue environment.

Polygalacturonase in *nor* tomato mutants infected with *Rhizopus stolonifer*

R.Barkai-Golan[37]
C.J.Brady
E.Kopeliovitch[38]

Rhizopus stolonifer infection stimulates ethylene and CO_2 evolution from fruits of the non-ripening tomato mutant *nor*, resulting in a climacteric-like pattern of respiration and development of red colour in mature fruits. To determine whether infection resulted in polygalacturonase production in infected fruits, observations were made on the fungal and fruit polygalacturonase. The fungal enzymes were separated into six isoforms by polyacrylamide gel electrophoresis; the three isoforms produced in normal tomato fruits could be distinguished from the fungal enzymes on polyacrylamide gels, and also immunologically. *Rhizopus*-infected *nor* fruit contained only fungal isoforms of polygalacturonase and had no reaction with antibodies to tomato polygalacturonase. *Rhizopus*-infected normal fruit contained both fungal and tomato isoforms of the enzyme measured immunologically. *Rhizopus* infection apparently advances ripening in normal tomato fruits, but the apparent ripening of mutant fruits is abnormal.

Ripening in tomato fruits: changes in messenger RNA

C.J.Brady
E.Lee
W.B.McGlasson
J.Speirs

Application of ethylene or propylene to mature, green tomatoes induces ripening which is apparent after 48 h as an increase in endogenous ethylene production and an increase in respiration rate. A recruitment of ribosomes to polysomes and the appearance of a small number of specific messenger RNA molecules are observed within 48 h. To test whether the messenger RNA molecules, which appeared during ripening, were specifically associated with ripening, observations were made on propylene-treated immature fruits and on wounded tissue from mature, green or ripe fruits. Treatment of 80%-developed fruits with propylene resulted in an increase in respiration and a recruitment of ribosomes to polysomes but not in an increase in ethylene production, nor in the appearance of those messenger RNA which appear in ripening fruit. The immature fruit treated with propylene for 48 h

did not commence ripening within six days. Wounding either mature-green or ripe fruit resulted in increases in respiration and ethylene production and in a large increase in polysomes within one hour. Wounding also induced an increase in the green fruit of some but not all of the messenger RNA molecules which appeared during ripening. The experiments allow a segregation of the ripening-associated messenger RNA into those which are ripening unique and those common to ripening and wounding. Current emphasis in cloning work is on the ripening-unique RNAs.

Ripening in tomato fruit: the transition from chloroplast to chromoplast

C.J.Brady
R.G.Hiller[3]
W.B.McGlasson
M.Olive[3]
J.Speirs
P.Wrench[3]

In a collaborative project with Macquarie University, observations were made on the changes in the proteins of the plastid membranes as the chloroplasts were dismantled and carotenoids accumulated in the chromoplasts. Methods of recovering chloroplasts and chromoplast membranes were developed, and the membrane proteins separated by polyacrylamide gel and characterized immunologically. The light-harvesting complex of tomatoes was shown to include five polypeptides within the range from M_r 21 900 to 26 300; these all declined in a coordinated manner as chlorophyll was lost from the plastids. The four polypeptides of the photosystem I complex declined at the same time. In contrast, polypeptides of the chloroplast coupling factor persisted through ripening and were present in purified chromoplasts. The chromoplasts contained some membrane proteins which were not apparent in membranes recovered from green fruits that had not begun to ripen; immunological studies were initiated to test whether these proteins are absent before ripening begins and may, therefore, be the products of genes activated during ripening.

Polygalacturonase enzyme from avocado fruit

C.J.Brady

Polygalacturonase was purified from avocado fruit using a combination of ion exchange, molecular sieve and affinity chromatography. The enzyme, of M_r 47 000, was a basic glycoprotein containing 6% neutral carbohydrate as mannose, fucose, arabinose, galactose and xylose; it also contained glucosamine. Although chemically related to the polygalacturonase of tomato fruits, the avocado enzyme was not recognized by antiserum specific for the tomato enzyme. Antibodies to the avocado enzyme were raised in rabbits.

Protein synthesis and respiration in senescing, cultured pear cells

C.J.Brady
R.J.Romani[39]

Attempts to understand the nature of senescence in normal fruit tissue are hindered by the bulky nature of mature tissues which makes pulse/chase type experiments impossible or inefficient. Cells from pear fruits can be maintained in culture in a non-growing condition. They undergo senescence within the culture over several weeks, and in some respects serve as a model for senescing cells in bulky organs.

The cells responded to varied oxygen concentration in the same way as whole tissues. Carbon dioxide production decreased with oxygen concentration in the range from 10% to 1% and there was a concomitant decrease in protein synthesis (fewer polysomes) and an increase in cell survival (decreased senescence). Maintaining an external sucrose supply resulted in a higher respiration rate, increased protein synthesis (more polysomes) and a decrease in cell survival. The presence of ethylene in the range 1-10 ppm increased respiration rate and sharply decreased cell survival but only if an external carbohydrate supply was present.

Methods for the isolation of plant messenger RNA

P.B.H.O'Connell

Messenger RNA (m-RNA) occupies a central position in the analysis of the genome by reverse transcription and cloning techniques, and in the analysis of the expression of the genome by *in vitro* translation techniques. The preparation of high quality m-RNA is an essential first step in such analyses. An extensive study of m-RNA of tomato fruit prepared by conventional methods and translated in the rabbit reticulocyte *in vitro* system indicated that a major gene product, the enzyme polygalacturonase, is apparently translated in low amounts. New approaches to the extraction and purification of nucleic acids have resulted in the design of chemical systems for the preparation of m-RNA that are easily performed and result in minimal enzymic degradation and minimal undesirable interactions with other cellular components.

GOSFORD HORTICULTURAL POSTHARVEST LABORATORY

This Laboratory is operated jointly with the NSW Department of Agriculture. In addition to studies on postharvest fruit and vegetable problems it is also responsible, under the auspices of the Fresh Fruit Disinfestation Sub-Committee, a joint Commonwealth and State body, for work on insect disinfestation of fresh fruit.

Fungicide investigations

Concentration determination by bioassay

H.J.Smith[7]
K.R.Ward[7]
B.L.Wild[7]

The fungicide guazatine is widely used postharvest to control citrus blue and green mould, *Penicillium digitatum* and *P.italicum*, respectively, and Sour Rot (*Geotrichum candidum*). Problems occur because the fungicide is readily stripped from solution by suspended dirt and the chemical analytical method for measuring the concentration of fungicide in dip tanks is subject to interference by several factors.

An alternative and more accurate bioassay procedure was therefore developed. The method relies on measuring the zone of inhibition of growth of *G.candidum* produced by loading 6-mm paper discs, containing the fungicidal solution, onto plates seeded with the organism. The diameter of the zones of inhibition were directly proportional to the log of the concentration of fungicide being tested. This process is also suitable for determining fungal activity in dips containing mixtures of fungicides such as benomyl and guazatine. Benomyl does not affect the growth of *G.candidum*, but if *P. digitatum* is used to seed the plate, total antifungal activity of a mixture can be measured as this organism is sensitive to both compounds.

Control of 'gas burn'

K.R.Ward[7]
B.L.Wild[7]

Previous experiments established that 'ethylene gas burn' associated with degreening early season Washington Navel oranges was due to the development of anthracnose caused by *Colletotrichum gleosporioides*. It was not known if it was the sole cause of burn over a wide range of ethylene concentrations or if the gas burn could be alleviated by the post-

harvest treatments. Results show that injury was reduced by hot benomyl and prochloraz dip treatments at all ethylene concentrations up to 2000 µg/ml (approximately ten time the normally recommended dose of ethylene). Washing and brushing the fruit before degreening was also very effective.

China project

B.L.Wild[7]

The cooperative establishment, between the Australian and Chinese Governments, of a citrus demonstration farm at Lingling advanced to the stage where a citrus packing line and storage rooms were constructed. The advisor on the postharvest section of this project visited the site and initiated experiments on the postharvest handling of citrus. Experiments were conducted to estimate the fungicidal usage rate and effectiveness of the new packing line and to evaluate the two cool night air storage rooms. The best storage temperature was determined for the local mandarins.

Fungicide and mould strain testing service

H.J.Smith[7]
B.L.Wild[7]

Postharvest mould control and citrus marketing rely on prompt dipping with an effective fungicide at the recommended strength. Because all fungicide concentrations decrease during usage, periodic checks of fungicide strength are necessary. The Gosford Laboratory offers a service to packinghouse operators so concentrations of fungicides can be determined. If full control is not achieved, mould strains will be checked for fungicide resistance. This service is made possible by the appointment of a Trainee Technical Officer under the Government training program for women.

Vegetable storage

Control of *Aspergillus niger*

S.C.Morris[7]
K.R.Ward[7]

Semi-commercial scale trials were performed on onions to determine the efficacy of a prochloraz dipping treatment and forced-air drying. Infection by *A.niger* decreased from 52% to 5% and levels of bacterial rot were reduced from 20% to 7% by prochloraz dipping and drying. An airflow of 20 m^3/min per bin for two days was effective in drying the onions after dipping. Residue levels and stripping rates during dipping are being determined to facilitate the registration of prochloraz for use on onions.

Potato greening

S.C.Morris[7]
K.R.Ward[7]

The evaluation continued of glycoalkaloid levels of additional potato cultivars being grown throughout New South Wales. This will provide information on the levels of glycoalkaloid to be expected from each region. Results to date indicate that potatoes grown in hot dry climates have glycoalkaloid levels up to 60% higher than those from cooler tableland climates. Further development of the h.p.l.c. analysis of glycoalkaloids has shown that use of α-solanine as an internal standard considerably improves the accuracy of analysis.

Postharvest tomato decay

M.Forbes-Smith
S.C.Morris[7]
N.L.Wade[7]

The cause of variability in infection of artificially inoculated tomatoes is still being investigated. Variables such as temperature, humidity, inoculum concentration and severity of injury are not well correlated with subsequent infection levels. The ability of the tomato to suberize wounds and the nature of water uptake through small wounds are being

studied. Propiconazole gave the most consistent control of both *Erwinia carotovora* and *G.candidum* in last year's experiments. Development of a low cost automatic pH and chlorine concentration controller is proceeding.

Disinfestation investigations

Cold sterilization of fresh fruit

C.J.Rigney[7]
R.J.Smith[7]

As an immediate alternative to disinfestation with ethylene dibromide fumigation, methods of cold sterilization of Queensland fruit fly in oranges are being determined. Storage of infested fruit at 1.5°C ± 0.5°C for a period of 16 days is sufficient to ensure 100% mortality of Queensland fruit fly at the three stages of development: eggs, young larvae and old larvae.

Chilling injury in fresh fruit

C.J.Rigney[7]
S.M.West[7]

As part of the work on cold sterilization, investigations are continuing on seasonal and geographical differences in resistance to chilling injury in the insect host, oranges, using fruit from South Australia, New South Wales and Queensland. Also, a study of six commercial orange packing sheds in South-East Queensland showed significant differences between orchards in the susceptibility of Valencia oranges to chilling injury.

Gamma irradiation and cool storage of apples

A.Jessup[7]
C.J.Rigney[7]

The effects are being determined of gamma irradiation on cool storage of different apple cultivars. Ripe Jonathans, tree-ripened Granny Smiths (post-climacteric) and green (pre-climacteric) Granny Smiths were irradiated at different doses and stored for various periods. Fruit are being examined every two weeks during storage for rotting and changes in physical characteristics of the fruit.

TASMANIAN FOOD RESEARCH UNIT

The Tasmanian Food Research Unit has a staff of ten, four of whom (an engineer, a microbiologist and two technical staff) are engaged in a three-year term project entitled 'Investigation of key factors in the maintenance of quality from catching to consumer' which is funded from the Fishing Industry Research Trust Account.

Advice and assistance provided by the Unit to industry was enhanced by the return of a permanent member of staff from secondment to the Tasmanian Fisheries Development Authority and his appointment as official extension and liaison officer.

Ties with the Australian Maritime College were strengthened. Staff contributed to the first major seminar held at the College. Two students from the College spent three months at the Unit in partial fulfilment of their Graduate Diploma in Fisheries Technology. The Unit is expected to become a venue for project work for Diploma students in future years.

Quality assessment by demerit points

A.Branch[40]
H.A.Bremner
E.Gorczyca[12]
J.N.Olley
H.Rahman[41]
J.A.Statham
S.J.Sykes
A.M.A.Vail

A scoring system based on demerit points has been developed Fresh fish or shellfish is scored zero and as the material spoils, any change which can be seen or smelt is given a de merit point. Accumulated demerit scores plotted against days of storage on ice were obtained for four fish species from the North-West Shelf, for temperate species in ice and refrigerated sea water, and for tropical species caught on a fishing trip in Java. The development of demerit points per day was found to be sufficiently linear for a questionnaire to be programmed into a hand-held Casio personal computer so that the sum of demerit points can be read out as a grade for the product. Programmed computers have evoked considerable interest and are on loan for trial to the New Zealand Fishing Industry Board, and the ACIAR project at the Research Institute for Fish Technology, Jakarta, Indonesia.

Nucleotide analysis

A.M.A.Vail

Routine methods for the separation of nucleotide breakdown products were developed for fish and shellfish. For shellfish it is necessary to use paired ion chromatography and a 5 micron column (Novapak) for adequate separation of homarine and inosine monophosphate. The same column can also be used in the reverse phase mode with phosphate buffer at pH 7.0 for finfish.

Shelf-life of species from the North-West Shelf:

Finfish

H.A.Bremner
P.Kearney
J.N.Olley
A.R.Quarmby
J.A.Statham
S.J.Sykes
A.M.A.Vail

Four potential commercial species have been previously reported by TFRU to be highly acceptable and to have at least a three-week shelf-life on ice. Analysis of variance showed that 88% of the overall acceptability on storage was accounted for by flavour acceptability, 75% of the variance of which was related in inosine monophosphate (IMP) content of the flesh, and thus to K-value which is a measure of nucleotide dephosphorylation. The rate of change of K-value (IMP breakdown) for *Plectorhyncus pictus* (painted sweet lip) and *Lutjanus vittus* (no common name) was almost double that of *Argyrops spinifer* (long spined sea bream) with *Nemipterus peronii* (threadfin bream) intermediate, when all were stored on ice. The former two species rapidly produced hypoxanthine with no marked inosine build-up, while the latter two species accumulated inosine and, when steamed, were highly acceptable for at least a week longer than the hypoxanthine producers. The rate of accumulation of demerit points for whole fish was similar in all four species. Thus, these external properties relate to remaining shelf-life and marketability based on appearance, while K-values relate more to the impression of quality when the fish is eaten.

The four species of fish supported a similar bacterial flora of *Moraxella* and *Vibrio/Aeromonas* types. No increase in bacterial numbers occurred until after nine days storage in ice, after which the bacterial flora was composed almost exclusively of *Pseudomonas* species, probably derived from the ice.

Scampi

H.A.Bremner
J.A.Statham

Three potentially commercial species of scampi, *Metanephrops andamanicus*, *M.boschmai* and *M.australiensis*, were studied during the February 1984 cruise of FRV-Soela to the North-West Shelf and advice was given on the handling of these

species. Because of the remoteness of this Australian fishery, it is likely that freezing at sea will be the best technique for preserving the catch. *M.australiensis* and *M. boschmai* are particularly attractive in appearance and may be marketed as frozen whole.

Storage trials were done with whole *M.andamanicus* held on ice, and on whole scampi and tails of all three species frozen on board directly after catch, thawed and held at 4°C. The iced samples deteriorated in appearance within 2-3 days, due to melanosis and digestive enzymes, while the chilled whole samples at 4°C deteriorated within a day. However, the cooked flesh from thawed scampi remained acceptable for up to 8 days at 4°C or 16 days at 0°C. Thawed scampi tails showed less visual deterioration in chilled storage and rated significantly better after 8 days at 4°C than the whole scampi.

The acceptability ratings of chill-stored thawed scampi were not consistent with K-values or bacterial numbers or types as is typical of finfish spoilage. The native bacterial flora was difficult to isolate and appeared to be susceptible to freezing. The spoilage flora on iced *M.andamanicus* could not be subcultured for identification, and less than 100 c.f.u./g of bacteria were usually isolated from thawed whole scampi and scampi tails using a conventional nutrient medium. Although *Alteromonas putrefaciens* was present in numbers between 10^6 and 10^7 c.f.u./g on scampi flesh stored 8 days at 4°C, the acceptability of the cooked flesh remained high.

Modified atmosphere packaging

H.A.Bremner
A.R.Quarmby
J.A.Statham

The benefits of a combination of potassium sorbate and carbon dioxide with added polyphosphate to prevent expected drip loss has been assessed with morwong (*Nemadactylus macropterus*) fillets (pH 6.75) stored at 4°C.

The time taken for total counts to reach 10^6 c.f.u./g on fish dipped in 1.2% potassium sorbate and 10% polyphosphate was increased from 9 days to 20 days by packaging in a 100% CO_2 atmosphere. The resulting spoilage flora was dominated by *Bacillus thermosphacta*. With 100% CO_2 alone, a level of 10^6 c.f.u./g was reached in 2-3 days and *Vibrio/Aeromonas* spp. predominated, the combination treatment giving a shelf-life of three weeks at 4°C.

Histamine production in fish

C.G.Garland[42]
E.Gorczyca[12]
N.Indriati[43]
T.A.McMeekin[42]
J.N.Olley
P.I.Pennington[42]
P.Poewardi[43]

Growth of specific microorganisms is accompanied by a constant mass of end-products under fixed conditions. Attempts were made to relate histamine production in fresh and dried salted fish to the growth characteristics of psychrotrophic, mesophilic and halophilic bacteria. The papers presented at a Workshop held at TFRU on this subject under the auspices of the FAO-IPFC Regional Program of Collaboration in Fish Technology Research were published. Stored samples of salted dried chub mackerel (*Rastrelliger neglectus*) from Indonesia were contaminated with the following bacteria which are tolerant of 22.5% salt: *Micrococcus*, *Halobacterium* and *Halomonas*. None of these organisms produced histamine on a modified Niven's medium, although the compound was detected in the dried fish samples.

Tropical fish

P.E.Doe[42]
J.N.Olley
S.Putro[43]

Coordination of the ACIAR project 'Prediction and control of spoilage of fresh, cured and dried fish' continued and the first annual report was submitted.

Air blast freezer

S.J.Sykes

A pilot-scale air blast freezer was designed, installed and commissioned. Tylose is being used as a comparative standard test material for assessing freezing rates in different commercial fibreboard packages. Future testing will cover the freezing of irregularly-shaped products such as abalone and lobster.

Loading a carton into the air blast freezer

LIAISON AND EXTENSION

G.Fisher
K.C.Richardson
P.J.Rutledge
G.J.Walker

Industry liaison officers, with the assistance of some members of the research staff, continue to answer a large number of technical inquiries. These responses range from providing published information to conducting experimental investigations either at the Laboratory or at a manufacturer's own establishment. Every effort is made to visit food processing plants, although this is not always practical with interstate inquiries.

In addition to these responses, some 40 commercial samples were examined at the Laboratory during the year. This service is extended to the industry to assist manufacturers when the Division has special expertize in an area of food technology. Problems covered in this way included investigations of microbiological spoilage, heat penetration studies, shelf-life determinations and water activity measurements.

The demand for FRL to provide speakers for technical and general community groups continues. Many technical education centres seek the assistance of FRL to supply specialist lectures in various aspects of food technology.

Consumer liaison activities centre on answering direct inquiries from the public and providing copies of the CSIRO Consumer Service leaflets either directly or to bodies such as municipal councils or schools which have proved effective in distributing this material.

MEAT RESEARCH LABORATORY

MICROBIOLOGY AND BIOTECHNOLOGY

Vacuum-packaging

Microbiology and storage life of packaged pork

A.F.Egan
I.Griffiths
D.Miller
B.J.Shay

Further storage trials at 0°C and 5°C confirmed the difficulty of obtaining an adequate storage life for vacuum-packaged pork, because of the high incidence of meat with pH greater than 6.0. Problems with an inadequate storage life of vacuum-packaged lamb carcasses intended for export were solved by the development of a treatment with dilute acetic acid before packaging. It consists of dipping the meat for 10 s in a dilute solution (1.5% v/v) of acetic acid at 55°C and was also applied to pork.

This treatment reduced the level of viable bacteria initially present by about 90% and a residual bacteriostatic effect was observed following packaging and storage. Acetic acid treatment was most effective against the Gram-negative microflora and least effective against the lactic acid bacteria. The treatment increased the storage life of vacuum-packaged high pH pork at 0°C to six weeks, but there was no significant extension of storage life for pork stored at 5°C.

Removal and detection of residual oxygen in vacuum packs

B.A.Bill
I.J.Eustace
R.A.Gibbons

A problem experienced by meatworks during the vacuum-packaging of lamb carcasses has been the implosion of packs into the carcass cavity when the packs were subjected to hot water treatment to shrink the packaging film. An alternative means of achieving low residual oxygen concentrations within the packs without the use of high vacuum may be by inclusion of oxygen absorbent materials. Work has commenced to determine whether commercially-available sachets of such materials are suitable for this purpose. Tablets which indicate decrease in oxygen concentration to less than 0.1% by changing colour are also under test. Their performance appears to be impaired by exposure to light and high CO_2 concentrations.

Hydrogen sulphide production by fermentative Gram-negative bacteria

F.H.Grau
P.B.Vanderlinde

A number of H_2S-producing bacterial isolates from vacuum-packaged meat were identified to genus level and from these 11 strains selected: *Aeromonas hydrophilia* (2), *Serratia liquefaciens* (3), *Yersinia intermedia* (4), *Enterobacter cloacae* (1), and *Proteus morganii* (1). All could produce more than 100 n moles of H_2S/ml from cysteine in laboratory media. In the presence of oxygen, all strains produced significant amounts of H_2S (75-330 n moles/g) when grown on lean of high pH (6.2-6.6) at 5°C. Under strictly anaerobic conditions, H_2S production was severely reduced for all strains except for *P.morganii*. Only this strain was as active in producing H_2S from high pH lean anaerobically as was an H_2S-producing lactic acid bacterium. The amount of H_2S produced by anaerobic growth on fatty tissue was small for all of the Gram-negative strains except for *P.morganii*, which produced more. However, *P.morganii* produced considerably less H_2S from fatty tissue than from high pH lean.

Washed cells of the Gram-negative strains, prepared from cultures grown in laboratory media, immediately produced H_2S

from cysteine. The rate was stimulated by either glucose or oxygen. When washed cells were added to high pH lean and the lean incubated anaerobically, *P.morganii* produced considerable amounts of H_2S, whereas barely detectable amounts were formed by *S.liquefaciens* and *Y.intermedia*. The rate of anaerobic production of H_2S by *P.morganii* was strongly influenced by the pH of the lean. Lactate was shown to inhibit H_2S production from meat blends at pH 5.6 but not at pH 6.6. The addition of 10 mM glucose to high pH lean had no effect on the rate of H_2S formation.

Lactic acid bacteria

Sulphide production

A.F.Egan
P.J.Rogers[44]
B.J.Shay

The level of cysteine desulphurase in cells of H_2S-producing lactic acid bacteria depends upon the composition of the growth medium. During growth on glucose only, enzyme activity was very low whereas on cysteine, enzyme activity was high. Cells growing on media containing equimolar amounts of glucose and cysteine did not produce H_2S. These results have implications for meat spoilage. Strain L13 produced H_2S sooner during growth on high pH beef (which contains very little glucose) than on meat of low pH. The addition of glucose to the high pH meat delayed H_2S production. Thus the presence of available glucose appears to prevent the utilization of cysteine and hence to delay H_2S production and spoilage.

A plating medium which will allow the direct quantitative estimation of lactic acid bacteria that produce H_2S is being developed. This is based on the medium used in the stab-inoculation procedure mentioned in last year's Report. When used in conjunction with conventional media for enumerating H_2S-producing Gram-negative bacteria, the direct determination of the total number of H_2S-producing bacteria present on meats should be possible.

Examination of H_2S-producing isolates for the presence of plasmids is continuing. To obtain efficient lysis of the cells in these experiments, the standard method (developed for streptococci) was modified and the presence of plasmids in H_2S-positive isolates was confirmed.

H_2S-producing lactic acid bacteria were first isolated from commercially produced beef of normal pH that had been vacuum-packaged but rejected because of greening. Using methods referred to earlier, they can now be readily isolated from packaged fresh and processed meats and appear to occur much more commonly than was first realized.

Media for enumeration

A.F.Egan
B.J.Shay

No satisfactory medium exists for the quantitative and selective enumeration of lactic acid bacteria in meat and meat products. The International Organization for Standardization (ISO) has formed a working group (ISO/TC 34/SC 6/WG 15) to devise methods to overcome this problem. MRL is collaborating in this international study. Preliminary experiments suggested several media that may be the closest to fulfilling the requirements. These include MRS agar (pH reduced to 5.7),

Rogosa agar (pH raised to 6.2), sorbic acid agar and nitrite-actidione-polymyxin agar. A more detailed program of experiments has commenced.

Irradiation

Packaged processed meats

A.F.Egan
I.Griffiths
J.J.Macfarlane
B.J.Shay
W.F.Spooncer
P.A.Wills[45]

The study of the effect of irradiation on the storage life and organoleptic quality of vacuum-packaged corned beef was concluded with an experiment in which meat was irradiated at 2.5-3.0 kGy. This dose was chosen as most likely to give a significant extension in storage life whilst causing only minor changes in flavour and aroma. Irradiated samples were stored at 5°C. Control treatments consisted of irradiated and normal (un-irradiated) meat stored frozen at -20°C. Whilst lactic acid bacteria were the main component on some irradiated packs stored at 5°C, others had populations in which Gram-negative bacteria were dominant (e.g. *Moraxella* up to 3×10^7/g). Taste panel evaluation showed that irradiated samples stored at 5°C had a storage life of 5-6 weeks. This contrasts with about 3 weeks determined previously for normal (un-irradiated) samples. Irradiation at 2.5-3.0 kGy caused flavour and aroma changes which, whilst significant, were rated by the panel as only 'slight'.

Thus irradiation can double the chilled storage life of this product. A dose of 2.5-4.0 kGy is appropriate, depending upon the magnitude of the organoleptic changes which can be tolerated in the market. Products with a stronger flavour and aroma (such as smoked ham) may better mask irradiation-induced organoleptic changes.

Determination of chemical lean content of meat

Sampling of boneless chilled meat

B.A.Bill
H.M.Chua
I.J.Eustace
R.A.Gibbons
P.N.Jones[25]
D.R.Smith

Contracts written between Australian sellers of manufacturing meat and overseas buyers, particularly U.S. buyers, frequently specify a minimum content of chemical lean meat. Australian meat packers usually determine the chemical lean (CL) content on chilled samples taken by coring from the cartons of meat before freezing. However, it has been suggested that estimates based on such samples can vary considerably from the estimates based on samples from frozen packs, the CL estimates on chilled packs being lower.

Manufacturing beef packed to 85% CL by a Queensland packer was sampled daily, both before and after freezing. Results from 27 sets of samples showed that the mean CL contents of samples taken from cartons before and after freezing were not significantly different. In a separate trial, 30 cartons of each of three products (boneless bull packed visually to 90% CL, boneless cow packed to 85% CL, and boneless mutton trunks packed to 75% CL) were sampled by each of three procedures:

- from chilled products, with a standard corer,
- from chilled products, with a modified corer, and
- from frozen products, with an auger.

Sampling of frozen meat yielded approximately three times the quantity of meat obtained by sampling chilled. The modified corer extracted about 20% more chilled meat than did the standard corer.

For the two sets of beef packs there were no significant differences between mean CL contents of the three sets of samples (standard corer *v.* modified corer *v.* frozen). For individual cartons of beef there was good correlation between results obtained before and after freezing. A better agreement obtained when the modified corer was used may well be a consequence of the larger and more representative samples taken. The results suggest that the variability obtained after sampling chilled product might be reduced by taking larger samples. For the bull beef packed visually to 90% CL, the mean CL content for the 30 cartons was 90.6%. The CL for individual cartons ranged from 78-97%. For the cow beef packed visually to 85% CL, the mean CL for 32 cartons was 81.3%, the range being 68-92%.

For mutton, analysis of mean CL when chilled product was sampled was significantly lower than for sampling from the frozen state. For individual cartons of mutton the correlation between analyses done before and after freezing was poor, making it unlikely that analyses of samples taken from chilled product in this test could be relied upon to predict analyses of frozen product.

The standard corer for chilled meat was modified a second time so that larger samples could be recovered. This corer removes at least as much meat as when the cartons are sampled frozen. The CL data on the chilled samples agreed well with the data on the frozen samples.

Production of pharmaceuticals from bile

Development of useful bile acid-catabolizing *Pseudomonas* strains

B.W.Arantz
N.Dunn[13]
J.Ide[13]
J.McDonald
R.J.Park

An Australian company signed an agreement with CSIRO and Unisearch Ltd (representing the University of New South Wales) giving it the right to examine the commercial potential of transposon mutant strains of bile acid-utilizing *Pseudomonas*. The company is examining, for the manufacture of marketable steroid drugs, the utilization of metabolites which these mutants produce from cattle and sheep bile acids.

The role of CSIRO in this project altered to one of an advisory nature to the company. However, further projects commenced in which different bile acid-utilizing mutant strains are being sought and methods of producing marketable drugs from these intermediates are being investigated.

Genetic manipulation of bile acid-utilizing *Pseudomonas* strains

D.J.Devine
R.A.Leppik
J.McDonald

Initially, some two hundred strains of bacteria capable of utilizing one or more bile acids for growth were isolated, and the majority shown to be *Pseudomonas* spp. The catabolic pathway used by one *Pseudomonas* strain for the degradation of the bile acids was elucidated. A number of the intermediates of this pathway were seen to be of potential value to the pharmaceutical industry. To learn the techniques for producing strains capable of accumulating the desired intermediates in high yield, an officer spent a one-year period (1983/84) working with Professor Timmis at the University of Geneva, Switzerland. Upon his return to MRL, a new laboratory was established for research on the genetic manipulation of *Pseudomonas*. The bile acid intermediates which would be needed in this study were synthesized. Transposon mutagenesis is now being used to produce the desired strains. Fourteen classes of mutant strains were isolated. Some of these classes accumulate novel compounds, as judged by thin layer chromatographic examination of extracts, and these are being isolated and identified.

Development of useful bile acid-catabolizing strains from Gram-positive microorganisms

J.McDonald
R.J.Park

Among the two hundred bile acid-utilizing isolates previously obtained were several Gram-positive bacteria. These catabolize bile acids by a pathway different from that of *Pseudomonas* spp. Among the catabolites are expected to be 9α-hydroxy derivatives which should be valuable intermediates for the production of certain corticosteroids and anabolic steroids useful for growth promotion in livestock. An attempt to obtain suitable mutants from the Gram-positive strains able to produce these intermediates is in progress. As a first step, the classification of the Gram-positive strains is nearing completion. Only two could utilize deoxycholic acid as sole carbon source, a requirement for any commercial application, and work is being concentrated on these two strains, which are phenotypically similar in many but not all characteristics. Attempts were made at mutagenesis of one of these strains but no useful mutants resulted.

Production of marketable steroid drugs from bile acid bioconversion products

B.W.Arantz
R.J.Park

Procedures will be developed for chemical conversion of the products of microbial metabolism to the finished pharmaceuticals. These investigations will be carried out in collaboration with the company which presently holds exploitation rights and with their consultants. Some progress has already been made toward converting one intermediate obtained by bioconversion of deoxycholic acid with one of the CSIRO-Unisearch transposon mutants into one such drug, by procedures applicable in commercial practice.

MEAT SCIENCE

Humane slaughter

Abattoir survey

P.M.Husband
B.Y.Johnson
F.D.Shaw
W.F.Spooncer

Abattoirs in several States were visited during a survey of existing methods for the stunning of cattle. The results indicate that, in general, the methods in use are satisfactory but problems do occur when slaughtering methods that comply with the requirements of certain religions are used. However, the running and maintenance costs of present methods do appear to be unnecessarily high and are labour-intensive.

Electroencephalography

W.K.Larnach[46]
F.D.Shaw
R.R.Weste

In assessing the humaneness of a particular stunning method it is desirable to use an electroencephalograph (EEG) to examine the electrical activity of the brain. Because of the complexity of EEG recording techniques its use has so far been mainly in experimental situations. Attempts are being made to simplify the recording of EEGs so that they may be used to investigate the stunning and slaughtering methods used in commercial abattoirs. The EEG is being used to assess the humaneness of the electrical stunning method being developed as part of the Alternative Slaughtering Techniques project.

Muscle

Pressure-accelerated degradation of proteins in muscle

J.J.Macfarlane
I.J.McKenzie

Studies of the mechanism of tenderization by pressure-heat (P-H) treatment are in progress because of the insight such information should provide into the associations between myofibrillar proteins that lead to toughness in cooked meat. In the SDS gel electrophoretograms of extracts of P-H treated muscle, it was noted that the treatment resulted in a small increase in a component of molecular weight of approximately 150 000, and the production of this component by pressure treatment was studied further. Its production appears to be maximal when meat is pressure treated at temperatures of 30°-40°C for some hours. The estimated myosin content of treated samples was significantly reduced, suggesting that the 150 000 molecular weight component was produced by enzymic attack on myosin. Although pressure treatment at 30°C reduced the Warner-Bratzler shear values of the subsequently cooked, cold-shortened muscle, the reduction was less than that achieved by P-H treatment. Therefore, although the mechanism by which the 150 000 molecular weight component is produced is associated with a degree of tenderization of cold-shortened muscle, it appears that another mechanism is primarily responsible for the tenderization achieved by P-H treatment.

Effect of P-H treatment on a protease system

L.Kurth
I.J.McKenzie

In studies complementary to those referred to above, leupeptin was shown to inhibit the P-H enhanced proteolytic activity of meat homogenates against the substrate Azocoll. This inhibition indicated that one of the proteases stimulated by the P-H treatment was likely to be cathepsin B. A crude extract of cathepsin B was prepared from bovine spleen and this protease system subjected to a variety of P-H treatments. Initial results indicated that the activity of a cathepsin B-like enzyme is accelerated several-fold by a pressure treatment of 150 MPa at 60°C.

Recombined meat

Processing factors

J.J.Macfarlane
R.H.Turner

As previously reported, interparticle binding in cooked recombined meat tended to increase when the temperature of the raw meat, when pressed into a consolidated mass, was reduced below the freezing point. In those experiments, after the product had been reformed it was stored frozen (at -30°C), as is common practice for such reformed products, before being cooked. Subsequent experiments showed that there is no difference in the binding strength of products reformed at -0.7°C and at -2.2°C if they are cooked

without first being cooled to -30°C. Subsequent freezing of reformed product at -30°C decreased the binding strength of that pressed at -0.7°C, but increased it for that pressed at -2.2°C.

Taste testing investigations

Effect of turnip weed (*Rapistrum rugasum*) on pork flavour

I.Griffiths
A.Takken[47]

An experiment was designed using eight levels of turnip weed ranging from 0% to 21% (in steps of 3%) in the feed of pigs. Four pigs (2 male and 2 female) were fed at each level. A trained taste panel evaluated meat aroma and flavour, other aromas/flavours and acceptability of pork derived from this trial. No significant difference was found between the treatments. However, the contaminant reduced the nutrient content of the feed, i.e. reduced weight gain.

Meat properties

Structural properties of beef

S.L.Beilken
P.V.Harris

By use of the isometric tension technique with sample treatments to accentuate one of the two main structural components of muscle, an investigation into the structural implications of different treatments was carried out on whole muscle with the Warner-Bratzler shear device. Using material from animals of different ages, these treatments were contraction state, preheating, pressure and connective tissue content. There appeared to be about six different zones or gradient changes which can be related to the thermal denaturation of muscle structural proteins.

Connective tissue toughness and animal age

S.L.Beilken
P.V.Harris
J.J.Macfarlane
W.R.Shorthose

Peak force (PF) shear values obtained for stretched muscles from beef animals of three age groups (2-3 mths, 2-6 yr and 12-17 yr) cooked for 1 h at temperatures between 40° and 95°C decreased above 50°, 55° and 60°C respectively. PF values obtained for veal muscles heated at 50°, 55° or 60°C for up to 8 h were unaffected at 50°C but rapidly decreased with time at 55° or 60°C. Elimination of the connective tissue contribution by a further cook at 80°C still showed a decrease in shear values with time. Samples from the oldest animals required 24-48 h at 60°C to produce a large decrease in the connective tissue contribution. Results were interpreted as showing that tenderization by extended cooking at 50°-60°C was achieved by accelerated ageing of the myofibrillar structure and, at ≥ 55°C, to a weakening of the collagenous connective tissue.

Breed differences in beef quality

P.V.Harris
W.R.Shorthose
T.J.Tierney[47]
J.R.Wythes[47]

In an experiment conducted by the Queensland Department of Primary Industries, the suitability of Simmental (high-grade) (S), Hereford (H), F_2 Brahman X Hereford (BH) and F_2 *et seq.* Africander X Hereford (AH) steers to produce feedlot beef for the South-East Queensland domestic market was determined. The criteria were carcass weight *c.* 180 kg and a subcutaneous fat depth over the loin at the 12/13th rib site of 6 to 10 mm.

Although S grew fastest and had the greatest carcass weight at slaughter, their carcasses were leaner than preferred for the feedlot beef trade. All carcasses were electrically stimulated with extra low voltage (ELV) within 5 min of stunning. Samples of *M.longissimus dorsi* (LD) were removed 24 h

postmortem from 23 carcasses in each breed group and held at 0-1°C for 48 h before cooking at 80°C for 1 h. Mean Warner-Bratzler initial yield values varied between 2.7 kg (S) and 4.6 kg (BH). Although the samples from the BH group had statistically greater shear values and cooking losses than the other three breed groups, differences were small and consumers would probably have considered all samples acceptably tender. Mean ultimate pH values were all low although the AH group had a significantly higher mean ultimate pH (5.43) than the other groups (≃ 5.40).

Colour stability of beef in retail display

B.P.Cain
R.F.Dickinson
D.A.Ledward[47]
V.H.Powell
W.R.Shorthose

It was previously reported that the colour stability in retail display of a muscle from the topside, *M.semimembranosus* (SM), from electrically stimulated (ELV) beef carcasses, was less than that of SM muscles from non-stimulated carcasses. A survey was conducted to determine if consumers could detect this difference when steaks were displayed in a retail cabinet for three days after slicing. Differences in consumer scores were small and statistically non-significant. Consumers perceived an increasing discoloration in displayed steaks with time (1-3 days) but no difference between steaks from stimulated and non-stimulated carcasses.

Experiments were done to determine how electrical stimulation increased browning (metmyoglobin formation) in some beef muscles. It was found that the rate of metmyoglobin formation depended on oxygen consumption rate and the activity of enzyme-mediated reducing systems. The activity of these reducing systems is, in practice, the more important factor and is affected by the temperature and pH conditions in muscles postmortem, ultimate pH, and the temperature, gaseous environment, and duration of storage.

Effect of D-penicillamine on intramuscular collagen

N.L.King
L.Kurth
F.D.Shaw

As an animal matures, slow chemical reactions in connective tissue lead to the formation of more stable covalent crosslinks between collagen polypeptide chains, so meat from older animals is often tough. One class of compounds thought to interfere with crosslink development is the aminothiols. When an aminothiol (D-penicillamine) was administered subcutaneously to lambs at 20 mg/kg/day for up to 30 days, Warner-Bratzler force values (a measure of meat toughness) were reduced by an average of 18%. Furthermore, the thermal transition temperature of intramuscular connective tissue was reduced by 0.7°C, indicating reduced stability of collagen in the treated muscles. This work is part of a project designed to study the nature of collagen crosslinking and its contribution to meat texture.

Electrical stimulation

Variability in effectiveness

S.L.Beilken
R.F.Dickinson
P.V.Harris
V.H.Powell
W.R.Shorthose

An investigation using high voltage electrical stimulation (ES) (800 VRMS, 1140V peak at 14.3 Hz) showed that lambs should be stimulated within 30 min of slaughter for 60-120 s for maximum effect on shear force values. Shear force values of lamb muscles chilled at different rates were significantly ($P<0.001$) reduced by ES, at all chilling rates, compared with unstimulated controls. However, ageing at temperatures between 0° and 9°C, for only 2-3 days, reduced shear force values of lamb subjected to moderate chilling rates to those achieved with ES samples after one day postmortem. Increasing ageing temperature significantly ($P<0.001$) increased ageing rate but had less effect than ageing time.

Consumer preference studies

Lamb

I.Congram[48]
R.F.Dickinson
J.Hall[48]
P.V.Harris
A.Hopkins[48]
W.R.Shorthose

The attitudes of Brisbane and Melbourne consumers to lamb were surveyed by the Livestock and Meat Authority of Queensland. A report on this attitudinal survey has just been completed. The responses of representative samples of Brisbane and Melbourne consumers to legs of lamb, loin or forequarter chops was also determined. These cuts came from lambs of known carcass weight and fatness that were chilled at two different rates. The ultimate pH, cooking loss, and shear values of LD muscles of all carcasses were determined at MRL. A report on consumer responses is being written.

Preslaughter treatment of cattle

Effects of rest *en route* to slaughter and/or at an abattoir on some properties of beef

P.V.Harris
V.H.Powell
W.R.Shorthose
J.R.Wythes[26]

LD muscle samples of cattle from two experiments conducted by the Queensland Department of Primary Industries were examined. One hundred and fifty Shorthorn and 20 Brahman X bullocks were transported 740 km to slaughter. Three groups each of 34 animals were delivered direct to the abattoir and two groups were rested for one day midway to the abattoir; lairage periods at the abattoir were 2, 3, 4, 2 and 3 days, respectively. In the second experiment, 240 Shorthorn and Brahman X cows were transported 1145 km to another abattoir. Three groups went direct to an abattoir, two groups were rested *en route* for one day and one group rested *en route* for two days. These groups were then rested at the abattoir for 1.5, 2.5, 3.5, 1, 2 and 1 days, respectively, during which time they had access to feed and water.

In terms of LD ultimate pH values, lowest mean values were achieved in groups which were sent direct to the abattoir and which were then rested for 3 or 4 days before slaughter. If results of both experiments are considered, the percentage of animals with LD ultimate pH values greater than 6.0 decreased linearly, $r = -0.75$, as total rest time (time rested *en route* + time rested at the abattoir) increased. Similarly, mean Warner-Bratzler peak shear force values decreased linearly with total rest time, $r = -0.6$.

Buffalo

P.V.Harris
J.Robertson[49]
W.R.Shorthose

In cooperation with the Northern Territory Department of Primary Production, assessments were made of some properties of LD muscles from cattle, domesticated buffalo and feral buffalo that had been rested at an abattoir for 1, 3, 5 or 8 days to determine whether increased lairage times could reduce the prevalence of dark-cutting meat in feral buffalo. All carcasses were stimulated (ELV) soon after stunning. In both species, ultimate pH values decreased almost exponentially with increasing time in lairage. The percentage of animals with LD ultimate pH values ≥ 5.8 was similarly reduced but even after 8 days in lairage there was a prevalence of 30% in feral buffalo. Cooking losses were inversely related to ultimate pH and increased with time. A 3-day lairage period reduced ultimate pH values in all groups and suggested that a lairage period of one day was insufficient to allow cattle or buffalo from that region to recover from preslaughter stress.

The changes in mean Warner-Bratzler shear values with time in lairage reflected changes in ultimate pH values but, because ultimate pH and shear values were curvilinearly related, depended much on the actual distribution of ultimate pH values within the slaughter groups. Thus, although within each type of animal group shear values were lowest in animals slaughtered after one day of rest, meat from them would have been very dark in colour. On average, meat from all slaughter groups was quite tender.

Branding of carcasses

Gelatine transfer system

F.J.van Doore
R.G.Hamilton
R.M.J.Vial

Approval was given to conduct commercial branding trials on beef for export to USA using gelatine labels carrying the small 'Australia Inspected' legends.

A small 'in-house' printer was designed and built to manufacture the labels on site for the trials. The machine, which is the result of a joint effort between MRL and Myers and Co., counts, prints and cuts the labels, then automatically packs them into cartridges for hand-held dispensers.

Petfoods

Formulation and evaluation

F.J.van Doore
R.G.Hamilton

Potential ingredients and selected commercial petfoods (wet, semi-moist and dry) were analyzed physically and chemically, and the nutritional requirements of cats and dogs reviewed. Fresh 'bone-in' hash (wet meat residue) was found to be a most suitable base for the formulation of semi-moist petfood because of its moderate moisture content and desirable nutritional characteristics.

A computer program was written to accept all the necessary data to generate test formulations which fulfil the nutritional, economic and shelf stability constraints. Three styles of product are being developed, each shelf-stable and each different from those currently on the petfood market. Experimental batches based on suitable formulations are being evaluated in animal feeding trials.

MUSCLE BIOLOGY

Biology of adipose tissue

Activation of ovine lipoprotein lipase

G.W.Johnson
R.F.Thornton
R.K.Tume

Lipoprotein lipase of ovine skeletal muscle and adipose tissues, like that from most other species, is dependent upon the presence of serum factors for maximal activity. These activators were isolated in a number of species and reside in the low molecular weight apolipoproteins.

Previously, sera from fasted sheep were shown to have a greater activating effect than those from fed sheep, but no gross differences were detected in the total apolipoprotein composition of these sera by sodium dodecylsulphate-polyacrylamide gel electrophoresis. However, brief incubation of

these serum samples with a triacylglycerol emulsion (Intralipid) resulted in the transfer of a number of apoproteins to the emulsion preparation and these remained firmly bound following extensive washing. About the same amount of total apoprotein was bound to the triacylglycerol from both sera, but lipoprotein lipase activating protein was a greater proportion of the total bound when serum came from fasted than from fed animals (12.2% *v.* 7.0% respectively). When these washed triacylglycerol emulsions were used as substrates for lipoprotein lipase assay at concentrations of 1.2 mM, the respective activities were 203 and 78 nmol fatty acid/g tissue/min.

β_2-adrenergic agonists and ovine lipid metabolism

T.W.Larsen
R.F.Thornton
R.K.Tume

The influences of clenbuterol, a β_2-adrenergic agonist, on lipid metabolism of isolated ovine adipocytes and the carcass meat composition of suckling/grazing lambs and pen-fed weaner lambs, were studied.

Clenbuterol decreased rates of lipogenesis and increased rates of lipolysis in isolated adipocytes. This suggests that clenbuterol may have induced an increased rate of the triacylglycerol-fatty acid substrate (futile) cycle in these cells.

The growth rate of lambs treated with clenbuterol was not different to that of controls in either growth experiment. Suckling/grazing lambs were slaughtered at a mean carcass weight of 16.0 kg which yielded 12.5 kg of boned-out meat, containing 24.6% fat in control animals *v.* 17.2% in clenbuterol-treated animals or 3.2 *v.* 2.1 kg of fat respectively. The pen-fed weaners were slaughtered at a carcass weight of 23.0 kg which yielded 19.3 kg of meat containing 38.3% fat in the controls *v.* 27.5% in clenbuterol-treated animals or 7.5 *v.* 5.3 kg of fat respectively. In both experiments the ~30% reduction in fat was replaced with an equivalent amount of lean tissue. Responses to clenbuterol were similar in ewe, wether and ram lambs and there were no apparent local or general ill effects in any of the lambs. Clearly, the metabolic consequences of treating lambs with clenbuterol are such that carcass fat deposition is decreased and protein deposition is enhanced.

Development and metabolism of intramuscular adipocytes

G.W.Johnson
R.F.Thornton
R.K.Tume

The growth, in tissue culture, of stromal-vascular cells isolated from intra- and inter-muscular fat is being investigated and their morphological and metabolic development into fat-containing cells is being followed.

Sarcoplasmic reticulum (SR)

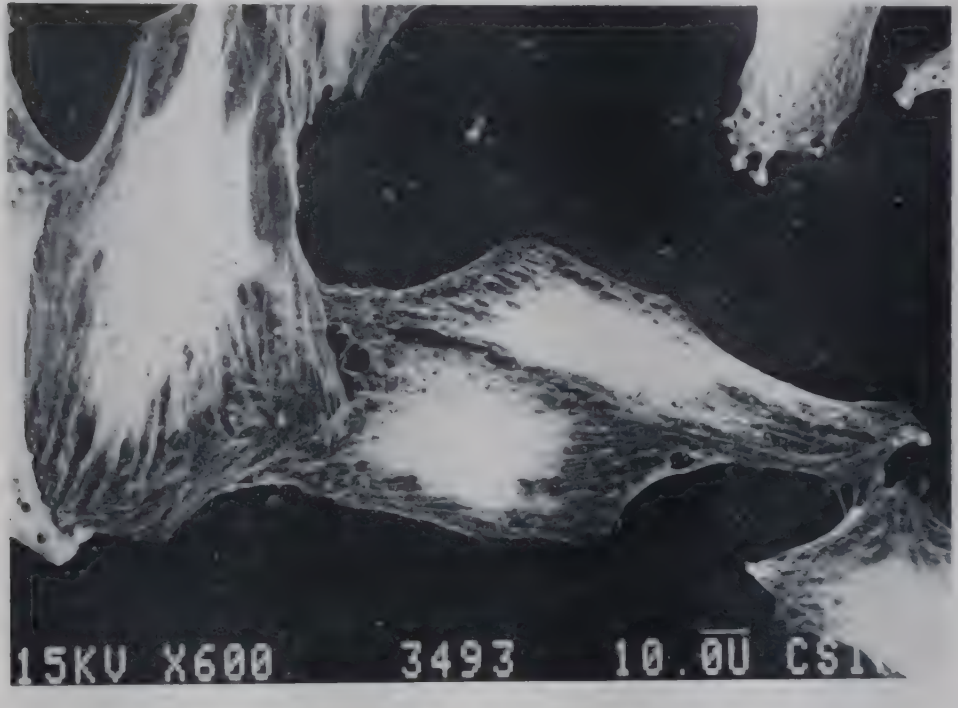
Basal ATPase and the effect of high pressure

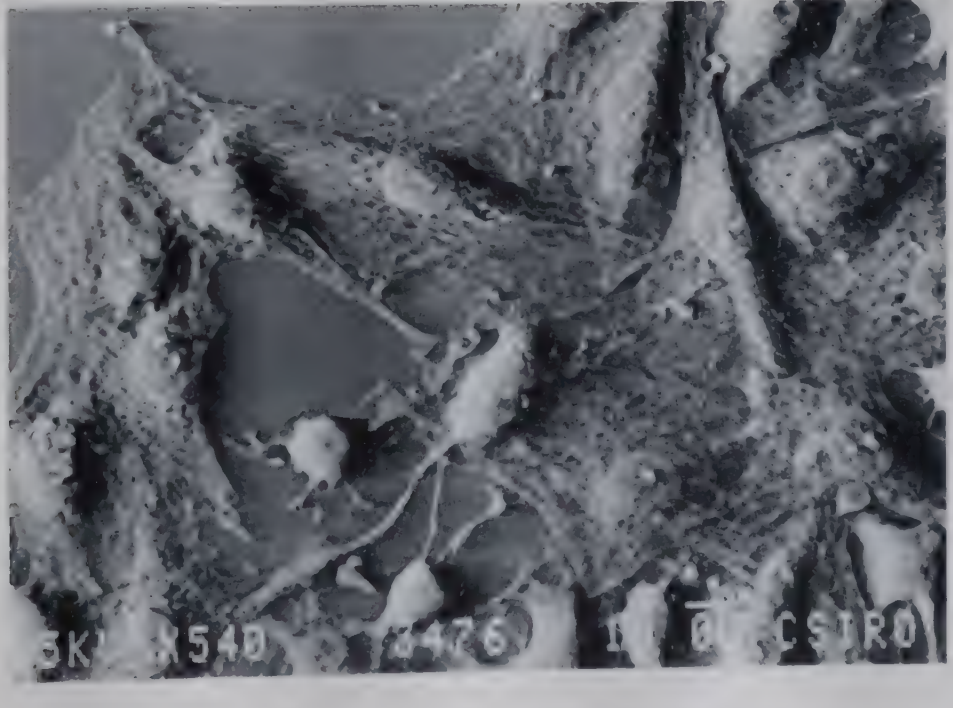
D.J.Horgan
R.Kuypers

SR preparations from muscles that were pressure-treated (150 MPa) for 10 min at 35°C had no extra ATPase activity but had a high basal ATPase activity. Sucrose density gradient centrifugation yielded two fractions with the lighter fraction being twice as active as the heavier. The light fraction was characterized by a high cholesterol content as was a light fraction of similar density found in normal SR preparations. The latter was similar, but not identical, to transverse

tubule preparations of other workers. Enzyme markers such as 5'nucleotidase and acetylcholinesterase indicated a surface membrane origin for both fractions from pressure-treated muscle.

Purification of the light fractions from normal and pressure-treated muscles by differential extraction of the membranes with lyso-lecithin yields highly active basal ATPase solutions. Protein patterns obtained by SDS gel electrophoresis of these solutions indicated that the light fraction from normal muscle SR had the same two major bands as reported for transverse tubules but the pressure-treated muscle fraction had a far more complex composition, possibly indicating that proteolysis had occurred.





Scanning electron micrograph of intact L6 myoblast cells of the rat. The cytoskeleton is visible as strands running towards the edges of the cell.

Glycolytic enzyme binding

F.M.Clarke[44]
D.J.Morton
J.F.Weidemann

The bulk properties of interactive mixtures of actin and glycolytic enzymes were examined by scanning electron microscopy and viscometry. This extends previous studies directed towards a demonstration that glycolytic enzymes play a constitutive role in the structure of the cytoskeleton of cells.

Morphologically distinct filament bundles were formed depending on which glycolytic enzyme was mixed with actin. At the same time there was a many-fold increase in the viscosity of the mixture as compared to the actin. The addition of the substrate of the glycolytic enzyme to the mixture produced changes both to the structure of the filament bundles and to the viscous properties. This suggests that the assembly of the cytoskeleton may be modulated by metabolic events within the cell.

To explore the *in vivo* role of glycolytic enzyme binding, red cell ghosts depleted in the glycolytic enzymes aldolase and glyceraldehyde-phosphate dehydrogenase were prepared. These ghosts had aberrant morphology which was restored to normal by adding back the enzyme. This implies that the membrane-bound part of the cytoskeleton is also under the influence of enzyme binding.

Backscattered electron imaging of cells in culture was developed to explore the organization of the cytoskeleton in intact cells.

STRUCTURE

Structural failure of meat under mechanical loading

R.W.D.Rowe

Investigations of the behaviour of the structural components of meat under various load conditions are continuing.

Between-muscle variability

R.W.D.Rowe

Tenderness variability between different muscles in a beef carcass can be very large. The structural variables most often investigated, i.e. muscle fibre contraction state and the connective tissue content, do not fully explain this variability. Therefore, differences in the organization of the connective tissue components between anatomically distinct muscles are being investigated.

Scanning electron microscopy and light microscopy enabled the elastin component of intramuscular connective tissue to be identified and its organization within different muscles is being studied. Elastin appears to have two distinct patterns of organization. Both patterns can be found in muscles that are routinely tough, whereas muscles with better tenderness ratings have only one of these elastin patterns present.

Variability in the collagen organization between muscles is quite distinct. Although all muscles examined so far follow the basic criss-cross pattern of collagen organization, the relative angles between the muscle fibre axis, collagen fibre axis and the overall muscle axis are consistently different between different muscles.

Heat denaturation of meat

R.W.D.Rowe

A systematic investigation of heat-induced modification of the structural components of meat is being carried out.

ENGINEERING STUDIES

Meat properties

Fat hardness

K.R.Davey

The sliding pin consistometer (SPC), developed for the objective assessment of the hardness of fat on sides of chilled beef, is being used to assess the effect of chilling practice on fat hardness for potential management of hard fat problems. By altering the chilling cycle within the requirements of regulatory bodies it might be possible to minimize hard fat. To find a wider market for commercial interest in the manufacture of the SPC, studies were conducted on a range of fat-based products. The SPC was shown to be better than available instruments for determining the hardness and spreadability of a range of butters and margarines over the temperature range that is of interest (0.8° to 25°C). Its potential in the cheese industry is being evaluated. The SPC appears to have an advantage over existing methods in that it is rapid and can be used directly on undamaged samples in their original packaging.

Carcass decontamination

K.R.Davey
G.M.Higgs
M.G.Smith

A pilot-scale hot water cabinet for the decontamination of carcasses was built based on an analysis and computer model of the problem. A novel method of assessing water coverage was developed and used to highlight minor modifications necessary to give a good coverage. Effort is being directed toward beef sides. The assessment of the effectiveness of the cabinet in reducing microbial contaminants of public health significance will commence soon.

Fat content of boneless meat

B.L.Baudistel
K.R.Davey
D.A.Lovett

The greater part of Australia's export boneless meat is used for manufacturing purposes and is sold in cartons of 27.2 kg with the maximum fat content specified, usually 15% by weight. Because there is no satisfactory on-line and accurate method for measuring the fat content of cartoned meat, it is common for exporters to include more lean meat than required in a contract - more lean is given than paid for. This practice represents a substantial loss in potential profit. Two different approaches to the on-line and accurate measurement of the fat content of cartoned meat are being assessed. The first is based on the difference in density between the lean and fat and a laboratory apparatus is being built to test this approach. A second aims at using nuclear magnetic resonance technology and is being carried out in collaboration with Griffith University, Nathan, Qld.

Computer simulation of meat cooling

D.A.Lovett

The advent of variable conditions for chilling of carcasses and cooling and freezing of boneless meat requires a more flexible approach to the solution of meat cooling problems than is presently available. Cooling conditions are often varied to reduce hard fat, minimize weight losses and make use of energy-efficient modes of operation. Studies showed that variable cooling, as well as usual chilling and freezing, can be simulated satisfactorily using a one-dimensional, three time-level, finite difference technique to solve the

related heat-transfer equations. A computer program is being written which can be run on small desktop computers, and will be made available to abattoir management. The aim is to assist managers to rapidly evaluate and optimize cooling problems in-plant.

Alternative slaughter technique

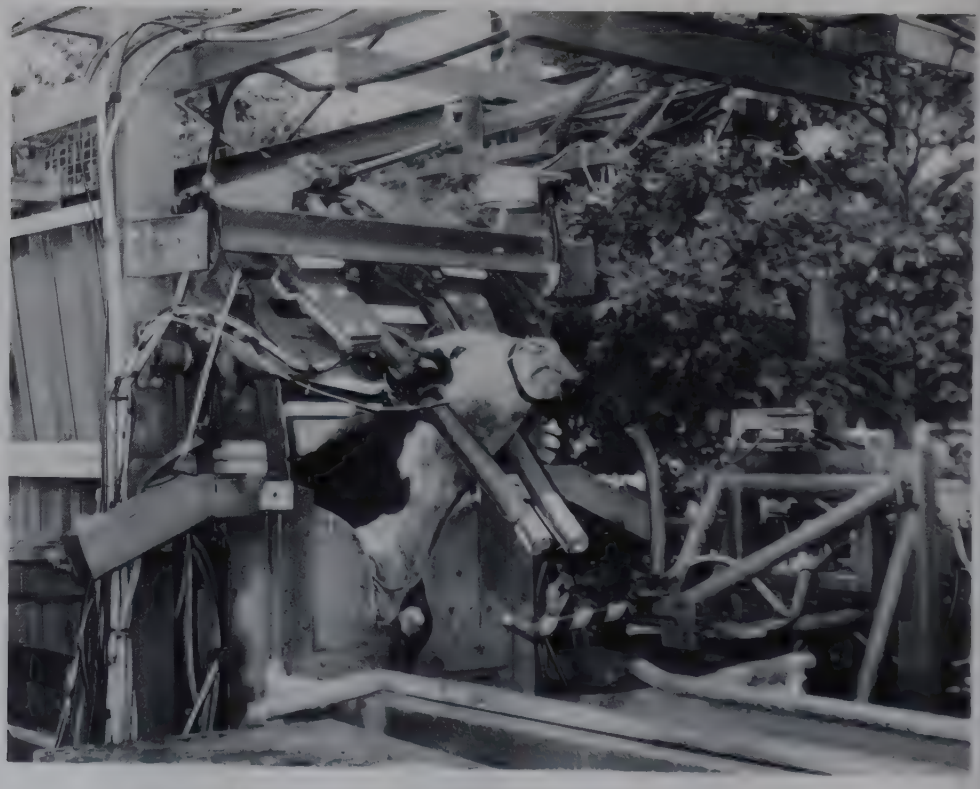
Cattle

P.R.Boyce
D.J.de Chastel
D.T.Kerr
R.J.Rankin
R.W.Tritchler
G.L.J.Wescombe
R.M.White

Further development and testing of the slaughter/dressing machine was carried out. Equipment for automatic horn cutting, hock cutting and brisket sawing was designed and built. Testing is under way. A sticking system is also being developed to enable automatic bleeding of the animal. When this is completed, only the hide removal system will remain to be developed.

Emphasis was placed on the automatic stunning of cattle using an electrical current. This method, which takes advantage of the head capture mechanism, is showing considerable promise. If successful, it will have substantial advantages for humane stunning, in particular for ritual slaughter of animals.

Funds are being sought to install the handling and capture part of the system in an abattoir for further testing and development.



Automatic capture and stunning facility

Humane stunning of sheep and cattle with microwaves

R.J.Rankin
G.L.J.Wescombe

Practical problems may be encountered in the operation of the stunning methods and the equipment currently used in commercial abattoirs leading to partial stunning which is often far from humane. Microwave energy provides a promising approach to a humane, automated stunning technique which is non-contact and so not affected by the presence of horns. The concept is based upon the focusing of microwave power into the animal's brain to produce a sudden temperature rise. Such a procedure should also be acceptable to Halal ritual slaughter requirements. Experiments are being carried out to determine the power requirements for a microwave stunning device, and so assess the economic feasibility.

Concussion stunning of cattle

N.G.McPhail

Concussion stunning using cartridge or pneumatically powered mushroom head stunners is generally less effective than penetrating and bolt stunning. Damage to the skull may also be severe enough for the carcass to be rejected for the Halal market. Skull damage was greatly reduced by enlarging the mushroom head of the commonly-used cartridge powered gun but stunning was less effective.

Meat product code

H.M.Chua

The development of the Meat Product Code (MPC) is carried out under the direction of the Meat Product Code Committee comprising CSIRO, meat industry associations, Department of Primary Industry and Australian Meat and Live-stock Corporation. It was agreed that a two-code system is to be adopted. The MPC consists of bar code, numeric code and product description. The carton identity code consists of a unique number and a bar code for each label/carton.

DAIRY RESEARCH LABORATORY

MICROBIOLOGY AND STARTER RESEARCH

Improved starter systems

Starter Culture Collection

A.V.Roberts

The Australian production of fermented foods such as cheese and yoghurt depends upon a supply of defined, viable and pure starter organisms. The CSIRO Starter Culture Collection is the only primary source facility in Australia providing this service. Cultures are prepared in a stable (freeze-dried) form and approximately 2000 per year are distributed to industry. The cultures include factory-derived bacteriophage-resistant starters and the number of manufacturers using them continued to increase. In addition, assistance is provided to industry, when resources permit, to help with starter problems.

Control of bacteriophage in cheese factories

Factory-derived technology

D.W.Eddy
R.R.Hull
J.J.Mayes
A.Orsini
S.Toyne

Cheese quality is critically dependent upon the reliable performance of starter culture streptococci in producing lactic acid during cheesemaking and in contributing to the development of desirable flavours as the cheese matures. The factory-derived starter system is used extensively in Australia. Problems encountered in manufacture over several years have highlighted two problem areas of this starter system: instability of cultures, and new disturbing phage.

Culture instability

M.R.Graham[50]
R.R.Hull
A.Orsini
R.S.T.Yu[51]

The instability of factory derivatives can be manifested by either a loss in fast-acid production or a reversion to phage sensitivity. The genetic techniques of transformation and conjugation are being used in an effort to transfer stable fast-acid-producing ability (lac^+) to these phage-resistant derivatives.

In studies of the mechanisms by which derivatives can lose phage resistance when used in the factory, sometimes within days, a number of derivatives were examined. It was found that the mechanism of resistance involves loss of the ability to adsorb phage.

New disturbing phages

D.W.Eddy
M.R.Graham[50]
R.R.Hull
S.Toyne

The mechanisms by which new disturbing phages are able to attack the derived cultures were studied. Raw milk phages are a type of disturbing phage found in Cheddar cheese factories, particularly where the factory-derived technology is in use.

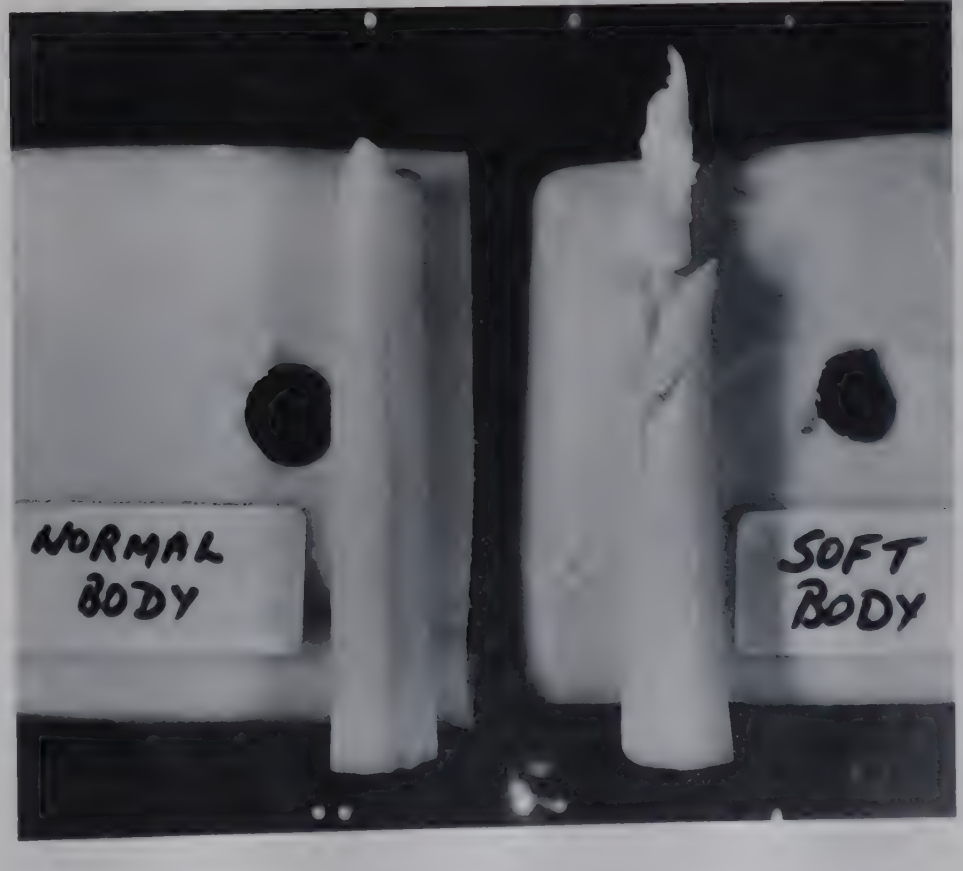
As reported previously the disturbing action of raw milk phages can be restored to near normal levels (i.e. that in

unheated milk) by the addition of Mg^{2+} (10-20 mM) to heated milk.

Examination of the kinetics of acid production showed that the reduction in disturbing action by raw milk phages in heated milk is due to their slower rate of multiplication. This resulted from a reduced average burst size due to all of the individual cells producing a smaller burst rather than only some of the bacteria producing a normal burst. The latent period was unaffected. Derivatives resistant to this type of phage can now be isolated either by supplementing sterile milk (autoclaved) with Mg^{2+} or by storing sterile milk at 5°C for 24 h.

In general, disturbing phages isolated from Cheddar cheese factories multiply more rapidly at the higher temperatures (35°-38°C) used in cheesemaking, compared to 25°-30°C as used in laboratory culture preparation. All those so far characterized have the same morphology (prolate head and a medium length tail) and all belong to one of two closely-related genetic groups of phage. Raw milk phages also multiply more rapidly at higher temperatures and the latent period of phage multiplication was found to decrease at higher temperatures causing the culture to lyse earlier (40% sooner than at 25°-30°C).

Phage-resistant derivatives selected at the temperatures used in the 'cooking' stage of Cheddar cheesemaking (35°-38°C) showed excellent resistance to phage during commercial cheesemaking processes.



Soft-body defect of Mozzarella cheese caused by contamination with *Lactobacillus casei*

Soft-body defect in Mozzarella cheese

R.R.Hull
J.J.Mayes
A.V.Roberts
S.Toyne

Pilot-scale experiments showed that the soft-body defect in Mozzarella cheese could be reproduced by adding *Lactobacillus casei* to milk. High brining and storage temperatures accelerated the development of this defect.

Using h.p.l.c. analysis, it was shown that the development of soft-body was associated with proteolytic breakdown of casein. The rate and extent of proteolysis was directly related to the concentration of the *L.casei* organisms in the cheese. The use of *Lactobacillus helveticus* var. *jugurti* strain LB1 as starter enhanced proteolysis whereas some other starters did not, thus helping to control this defect.

Phenolic flavour defect in Cheddar cheese

R.R.Hull
J.J.Mayes
A.V.Roberts

A phenolic flavour defect in cheese was shown to be associated with the contaminating organism *L.casei* subsp. *alactosus* which was isolated from defective cheeses and from rennet (same source as used in the manufacture of defective cheese). When added to cheesemilk in pilot-scale cheesemaking, they produced the phenolic flavour defect.

These organisms were not isolated from the contaminated rennet samples using standard lactobacillus media such as MRS agar, thus they were undetected in early testing. Conditions for their isolation from contaminated rennet were determined and, in conjunction with rennet manufacturers and cheese companies, a comparative trial is being carried out to determine the most suitable method. This work should assist in the formulation of appropriate standards for the bacteriological quality of rennet.

Role of lactobacilli in Cheddar cheese maturation

M.W.Hickey[51]
A.J.Hillier
D.Hungerford[51]

Lactobacilli isolated from mature Cheddar cheese were identified and characterized. Individual isolates were added to the cheese vat during manufacture and the cheeses analysed for protein breakdown and the release of amino-acids. Addition of some isolates to the cheese was shown to increase protein breakdown and accelerate cheese maturation.

Biochemistry of starters

Characterization of the lac plasmid from *Streptococcus lactis*

M.Angus[52]
A.J.Hillier
L.N.Lee[53]
D.J.LeBlanc[53]

S.lactis contains plasmid DNA which codes for some of the enzymes involved in the transport and hydrolysis of lactose by the phosphoenol pyruvate phosphotransferase system. In order to study the regulation of lactose metabolism in starter bacteria, a gene bank of *S.lactis* plasmid DNA was established in *Escherichia coli* and fragments of *S.lactis* plasmid DNA are being characterized.

Sugar transport and galactose metabolism in *S.thermophilus*

M.G.Achen[52]
C.Aitken[52]
A.J.Hillier

S.thermophilus is used in the manufacture of fermented dairy products which require high cooking temperatures (>40°C). However, when grown in milk this organism does not ferment the galactose moiety of lactose. The enzymes that are deficient in the galactose fermentation pathway were identified and *S.thermophilus* strains which ferment the galactose moiety of lactose are currently being isolated.

Molecular biology of streptococcal phages

Characterization of lytic phage

B.E.Davidson[52]
A.J.Hillier
I.B.Powell[52]
D.Tulloch[52]

Restriction enzyme maps of DNA isolated from a number of lytic streptococcal phages were constructed and the molecular biology of these phages is being studied.

Characterization of temperate phage

B.E.Davidson[52]
A.J.Hillier
L.Pulakat[52]
G.B.Westwood[52]

It was important to know whether the temperate phages present in lysogenic starter bacteria were related to and/or a source of the lytic phages which attack group N streptococci. DNA prepared from temperate phage showed no homology with the DNA from any of the lytic phages tested, which suggested that the lytic and temperate phages are not closely related. The genomic structure of temperate phage is being investigated.

CHEESE TECHNOLOGY

Applications of ultrafiltration (UF)

Two processes have been developed at DRL to utilize in cheesemaking milk concentrated by UF. These are the 'High-Yield' process for manufacture of natural hard cheese, and the 'Cheesebase' process for manufacture of this processed cheese ingredient. Both processes are continuing to interest manufacturers and are proceeding to commercialization.

Manufacture of natural hard cheese

F.Caldecoat
G.C.Dixon
N.H.Freeman
G.W.Jameson
W.P.King
I.Langdon[54]
H.J.van Leeuwen
K.Nguyen-Thi
G.Pettingill
R.J.Prince
D.R.Radford[55]
B.J.Sutherland
D.Taylor

Activity in this project was mostly under the auspices of a collaborative research and development agreement, and much of it was directed at providing design data for a full-scale prototype plant. Design data for for some plant components were derived directly from extensive operation of the continuous pilot plant. However, as some of the plant components represent radical innovations in cheesemaking equipment, it was necessary to conduct tests on a larger scale to obtain reliable design data. Accordingly, key components were fabricated of a size suitable for the commercial prototype, and were then tested and optimized with amounts of product sufficient to simulate actual operation at commercial scale.

Design of the first full-scale prototype High-Yield Cheddar plant was carried out under CSIRO supervision, and fabrication by the collaborative partners APV-Bell Bryant Pty Ltd is proceeding on schedule. The plant will operate during the 1985/86 cheesemaking season.

Cheese manufacturing trials using the continuous High-Yield pilot plant were largely directed at optimizing process parameters and selecting suitable starter strains. Performance of starters in the High-Yield system is not highly correlated with their performance in conventional Cheddar cheesemaking. Cheese quality was evaluated by professional graders from the Commonwealth Department of Primary Industry

and the Department of Agriculture, Victoria. The work of these graders was of great assistance in selecting preferred starters, in eliminating strains which appear to produce flavour defects, and in general optimization of process variables.

Laboratory studies of the starter system continued. A large number of strains were evaluated for growth and acid production capacity in retentate. An area of particular interest is performance of selected starter organisms during and after the High-Yield cheesemaking process compared with their performance in conventional cheesemaking. A major conclusion was that products of the two systems are similar, provided that starter cell densities are comparable. Work in this area is continuing.

A major laboratory study of protein breakdown in maturing High-Yield Cheddar was completed, and analysis of the data is proceeding. The objective was to determine whether the processes by which protein breaks down in conventionally-made Cheddar cheese were different from those in Cheddar made by UF. (These processes affect cheese body and provide precursors of cheese flavour). Analysis of soluble proteins and peptides by h.p.l.c. showed no major differences between High-Yield and control cheeses during the first three months of maturation, except in the levels of whey proteins in the cheeses. At a later stage (six months), the High-Yield Cheddar had higher levels of small peptides than controls. Differences in levels of free amino-acids were slight, except for the six months' High-Yield Cheddar which was marginally deficient in some amino-acids relative to controls. Peptidase activity in the two types of cheese was examined. Enzyme characteristics did not differ according to source, and variations in activity appeared to be directly related only to the number of starter organisms in the cheese.

In response to inquiries from several cheese manufacturers, it proved necessary to carry out individual cost/benefit analyses on a site-specific basis. The results vary with scale of production and price structures in different countries. However, they generally indicated a substantial economic benefit from installation of the High-Yield process.

Cheesebase for processing

K.Ajayoglou[56]
P.Hull
T.Mounsey
R.M.Shanley
P.Smith
B.J.Sutherland

The pilot plant and laboratory aspects of the major study of the interaction of seasonal variation with process parameters was completed. Data analysis is proceeding. Work commenced on the development and testing of an on-line moisture monitoring instrument for process control and quality assurance in cheesebase manufacture. A radiochemical method is being developed for quantitating milk proteins separated by SDS gel electrophoresis. It is being applied in a study of the chemical basis of some poorly understood, yet critical, process parameters.

A commercial facility for manufacture of cheesebase was installed and commissioned by the partners in this collaborative research and development project. Inquiries were received from other potential users of the process, and assistance was given in cost/benefit analysis of the process under conditions prevailing at specific sites.

Pilot-scale equipment used to prepare processed cheese

Manufacture of cheese

Cheddar cheese yield

V.J.Mackie
J.J.Mayes
B.J.Sutherland

The study of the effects of the duration of the rennet coagulation process on the yield of traditionally-made Cheddar cheese was extended to examine the effects of premature cutting and of varying the interval between cutting and the start of agitation, i.e. the 'healing' time. Limits below

which significant loss of milk constituents would be expected were established for curd strength at cutting. Reduction of 'healing time' tended to increase the loss of milk constituents to the whey stream, the losses being greater at lower curd strength.

Low salt and low fat specialty cheese

G.W.Jameson
V.J.Mackie
J.J.Mayes
B.J.Sutherland

This project was expanded to include a range of specialty cheeses suitable for the dietary market. Some preliminary manufacture of cheeses with reduced fat levels was carried out to define the extent of the problems which will be encountered. Manufacture of reduced-salt Swiss cheese continued. The extent of industry interest in the area is now being gauged.

MILK COMPONENTS

Milk powders

Changes in mineral balance

P.T.Clarke
F.G.Kieseker

Studies continued on the changes that occur in the soluble and colloidal phases of milk minerals as a result of processing. An extensive project in which milk was preheated at a range of time/temperature combinations for each of low, medium and high heat powders was completed and the results are being evaluated. Increasing the pH after preheating had only a minor effect on soluble mineral levels, but a decrease in pH increased soluble phosphorus to the level obtained in raw milk, and increased the level of calcium and magnesium. Increasing the pH before preheating resulted in a marked decrease in the level of soluble calcium.

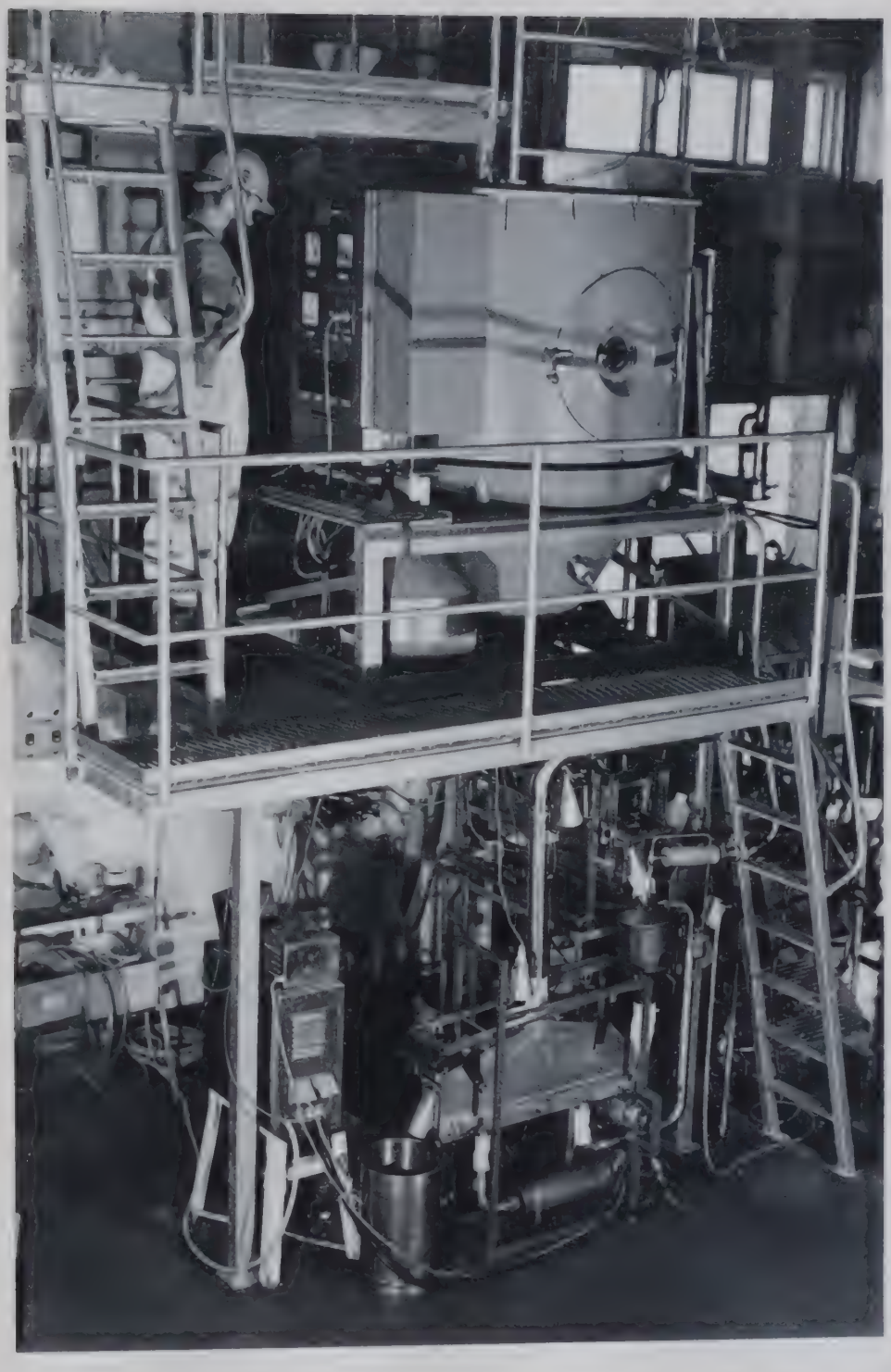
Preliminary studies on the addition of calcium before and after preheating indicate that the intensity of heat treatment and the point of addition have an influence on the availability of soluble calcium and, to a variable extent, on the soluble phosphorus in the preheated milk. These treatments reduced the viscosity of powders reconstituted to 30% total solids but resulted in a marked increase in viscosity levels when they were evaluated in recombined sweetened condensed milk.

Influence of whey and whey permeates on the properties of milk powders

B.Aitken
F.G.Kieseker

The use of membrane technology in the dairy industry has expanded to provide a wider range of by-products for utilization or disposal. These include milk permeates, wheys and whey protein concentrates (WPC), which could be used in some milk powders. However, such uses could create problems during subsequent processing, particularly when the specific functional properties of the powders are required.

In preliminary studies in which up to 20% of milk permeate was added to raw milk before preheating, concentration and drying did not result in marked changes in physical properties of the powder such as bulk density and solubility index. There was, however, a reduction in the level of protein and a decrease in calcium and magnesium. There were some variations in the heat stability of the high heat powders, depending on the level of addition. However, there were major increases in the inherent viscosity of medium-heat powders which would render them unacceptable for some processing applications.



Pilot-scale spray dryer and fluidized beds

Recombination

Recombined ultra-high temperature (UHT) evaporated milk

B.Aitken
J.F.Hardham
F.G.Kieseker
J.G.Zadow

Studies continued on the manufacture of recombined UHT evaporated milk (18% solids-not-fat, 8% fat) using low-, medium- and high-heat powders manufactured from the same batch of milk. Samples containing added mono-sodium phosphate gelled within a month while samples without this stabilizer had high viscosity and sedimentation increased during storage. Increasing levels of hexametaphosphate (0.05 to 0.125%) decreased the viscosity. The product made from high-heat powder with 0.1% hexametaphosphate demonstrated a stable

viscosity level and the best flavour after three months storage at 28°C. All samples exhibited a slight but acceptable level of fat separation.

Liaison with Asia Dairy Industries (H.K.) Ltd

B.Aitken
F.G.Kieseker

Samples of basic raw materials and recombined products are received from Asia Dairy Industries (H.K.) Ltd for chemical and physical analysis and organoleptic assessment both initially and after storage. Of particular interest was the appraisal and improvement of recombined instant full-cream milk powder manufactured in Indonesia, using the technology developed in this Laboratory. Other aspects include the sensory evaluation of recombined sweetened condensed milks manufactured from milkfat containing increasing percentages of palm oil, and a comparison of the storage stability of conventional and recombined evaporated milks. Of some concern was the number of non-fat milk powders which did not perform satisfactorily during processing. Laboratory trials indicate that these powders could contain added whey. A more extensive program was initiated to study the influence of such additions on the properties of milk powders.

Proteins

Fractionation of whey proteins

R.J.Pearce

The major whey proteins, beta-lactoglobulin and alpha-lactalbumin, may be separated by simple manipulation of the pH and temperature. While a laboratory-scale continuous process was readily achieved, technical difficulties were encountered in translating it into commercial operation.

A range of microfiltration systems was evaluated to achieve separation of the finely precipitated alpha-lactalbumin from the mother liquor containing soluble beta-lactoglobulin. These included plate and frame systems and hollow fibre configurations. A preliminary assessment indicated that the latter configuration was more effective, probably due to higher cross-flow velocity and smaller transmembrane pressure drop.

Estimation, occurrence and isolation of bovine milk lysozyme

H.A.McKenzie[57]
R.J.Pearce
F.H.White[57]

Because of the very low concentration of lysozyme in milk, a sensitive method for determining lysozyme activity was developed. The occurrence of lysozyme in the milk of Friesian and Jersey cows at the Milking Research Centre, Gilbert Chandler Institute of Dairy Technology, Werribee, Vic., was studied over part of a lactation. Some cows were consistently high producers, some were low producers and the rest were variable. This information was used to select cows for lysozyme isolation. 'High lysozyme' milk was treated to yield an acid whey. A series of steps including ion exchange chromatography, ammonium sulphate fractionation and gel filtration was used to purify the enzyme. Amino-acid composition and sequence determinations are in progress.

Manufacture of sunflower protein isolate

S.M.Claughton
W.Cougle
V.J.Mackie
R.J.Pearce

A pilot-scale continuous system was established which appears to be readily adaptable to commercial operation. Yields of sunflower protein isolate were achieved approximating those obtainable in the laboratory. The isolated protein has a colour comparable to commercial vegetable protein isolate and should be acceptable to the food industry. Its value in food manufacturing will depend on results from studies of functionality and food product development.

Using pilot-scale equipment to prepare sunflower protein isolate

Characterization of sunflower protein isolates

W.Cougle
R.J.Pearce

Biochemical characterization of sunflower proteins continued, using electrophoresis and gel chromatography. Electrophoresis in SDS allows the subunit polypeptides of sunflower to be enumerated and their respective molecular weights determined. Analysis of many batches of sunflower protein isolate obtained using the pilot-scale process showed that a consistent polypeptide electrophoretic pattern developed. Ascending gel filtration chromatogrphy using Sephacryl S300 yielded reproducible elution profiles showing a single major protein peak, in contrast to most vegetable-derived storage proteins, which show two major components.

Functional properties of sunflower protein isolates

K.Cheah[12]
S.M.Claughton
R.J.Pearce

Studies on the functional properties of sunflower protein isolates continued, with emphasis on solubility and emulsifying properties. This protein shows typical globulin solubility behaviour, being poorly soluble near the isoelectric point but substantially soluble at both higher and lower pH values. Standard procedures for determination of non-protein nitrogen (NPN) components caused some difficulty. Reagents such as trichloroacetic acid and phosphotungstic acid, used

as protein precipitants, resulted in incomplete protein precipitation and consequent high apparent NPN values. Physical techniques such as dialysis and ultrafiltration were therefore necessary to obtain meaningful NPN data. Solubility *v.* pH profiles were obtained over the range of sodium chloride concentrations that is found in foodstuffs. While solubility at high pH was reduced with increasing salt concentration, solubility near the isoelectric point was increased.

A new approach to the measurement of emulsifying properties was pursued. Reported methods for determination of 'emulsion capacity' have relied mostly upon identifying the point of phase inversion during the addition of oil to an aqueous protein solution. This, however, results in an excess of variables and indeterminant data. A technique having only a single independent variable, the protein content of the emulsion, was developed. Protein concentration is varied as a linear gradient applied to a constant oil/water ratio.

UNIT PROCESSES

Lactose hydrolysis

Process development

M.Free
J.F.Hardham
J.F.Hayes
I.Mitchell
A.Mohyla
L.Webb
J.G.Zadow

Studies continued on the development of a versatile system, using an immobilized beta-galactosidase (lactase) from Sumitomo Chemical Company Ltd for hydrolysis of lactose in permeate, whey or skim milk. Early in 1984, a 50-l reactor using a reversible packed-bed system was installed in a Victorian dairy factory. This unit was used extensively for trials on hydrolysis of milk and whey, for evaluation of reactor performance characteristics and for determining the effectiveness of sanitation techniques. The reactor was also used for production of tonnage quantities of hydrolyzed products, samples of which were distributed to end-users for evaluation.

The lactase enzyme is immobilized on a resin. Initially, problems were experienced in adequately cleaning the resin after use. As the reagents and conditions that may be used for sanitation and storage of resin are severely limited by the sensitivity of the immobilized lactase to temperature and pH, there were additional problems in prevention of bacterial growth in the resin during storage. Improved techniques were devised, and storage and sanitation aspects appear satisfactory.

Reactor design is a major factor determining the maximum length of processing runs. As the system operates between 30° and 40°C, running times can be limited by bacteriological growth. Running times of more than 10 h are considered desirable in a commercial environment. Whilst this has been fairly easily achievable in the laboratory for hydrolysis of whey or permeate, difficulties were encountered in long trials on skim milk, using either packed-bed or reversible packed-bed reactors. An examination of the effect of fluidization of the resin on running time was therefore undertaken. Effective mechanical fluidization resulted in running times of up to 20 h in laboratory studies using skim milk as substrate, but trials using a larger-scale plant based on mechanical fluidization were not satisfactory. Preliminary trials using hydraulic/mechanical or purely hydraulic fluidization systems were promising, both in laboratory and pilot-scale operations.

A major factor controlling both fluidization and enzyme activity is the particle size distribution of the resin. The practical implications of this factor are being explored in collaboration with Sumitomo Chemical Company Ltd.

The dairy company collaborating in the project ordered a larger reactor system based on the technology developed. This unit will be based on the reversible packed-bed system. The plant is to be commissioned in mid-1985.

Product evaluation

M.Free
F.J.Hayes
I.Mitchell
A.Mohyla
L.Webb
J.G.Zadow

Samples of lactose-hydrolyzed skim milk powder made in the 50-l reactor at the dairy company were distributed to potential end-users in Australia and South-East Asia. The product was also displayed in a recombined form at a food exhibition in South-East Asia where it attracted considerable interest.

A number of Australian manufacturers expressed interest in lactose-hydrolyzed, reverse osmosis (RO) concentrated milk as a base for a no-added sugar or reduced-sugar flavoured milk. Large-scale production trials were carried out at the Gilbert Chandler Institute of Dairy Technology involving hydrolysis using the 50-l reactor and RO concentration. The samples are under evaluation by a dairy processor and a flavour company.

Studies on whey centred on hydrolysis of hydrochloric acid casein whey (rather than cheese whey), as certain factories are limited in their ability to manufacture casein because of restrictions on disposal of the whey. In general, lactose-hydrolyzed casein whey cannot be used as a protein-containing sweetener because of the low pH and high salt content. However, there is potential for this product in applications where the low pH and high salt content is a distinct advantage. Preliminary trials were undertaken to manufacture such a product as a high-solids syrup. However, supply of the hydrolyzate in this form posed problems both during manufacture and storage. Attempts to spray-dry the syrup were unsuccessful, probably due to the high monosaccharide content. The use of carriers in the product to allow for satisfactory drying is being examined.

Demineralization is necessary for some applications of hydrolyzed whey and permeate. RO membranes designed to allow the passage of minerals whilst retaining lactose are being examined in collaboration with several membrane manufacturers.

Whey protein concentrates (WPC)

Functional properties

J.A.Dunkerley
J.F.Hardham
H.R.Kocak
J.G.Zadow

Following the meeting of the International Whey Protein Functionality Group at DRL last year, a series of samples of WPC were prepared under strictly controlled conditions by the New Zealand Dairy Research Institute and distributed to the Group for evaluation. The functional properties of the samples were assessed in a number of physico-chemical tests and on incorporation into model systems. Results of these studies will be considered at a meeting of the Group in New Zealand in October 1985.

A wide range of coagula were developed by in-can sterilization of aqueous dispersions of Cheddar cheese WPC containing 12.5% protein. These coagula varied considerably in their physical, visual and organoleptic characteristics, depending on the pH of the initial dispersion. Strong coagula were formed with firmness at a maximum of 5 newtons (N) at pH 4.5, with other maxima at pH 6.0 (2.5N) and 8.0 (3.5N). These products appear to offer potential as the base for foodstuffs and the possibilities are being explored with industry representatives.

The characteristics of heat-formed coagula appear to depend to a large extent on the relative rates of the denaturation and aggregation stages. If aggregation is comparatively slow, the resultant coagulum will be expected to be less opaque and will exhibit less syneresis. If aggregation is more rapid, the coagulum will be more opaque and capable of holding solvent which can be expressed as serum. Conditions favouring denaturation (such as high or low pH) do not favour aggregation. These effects are clearly shown by the coagula prepared from WPC.

Ultra high temperature (UHT) treatment

Commercial trials

J.F.Hardham
J.J.Mayes

Following improvements to the UHT pilot plant, there was a considerable increase in the demand for assistance by industry in the development of specialist UHT products. Many new products based on dairy products were processed, as well as a range of other non-dairy products based on materials such as fruit juices or soy protein.

Recombined UHT concentrated milk

B.Aitken
J.F.Hardham
F.G.Kieseker
J.G.Zadow

Trials continued on the production of a storage-stable recombined UHT concentrated milk. Significant differences were observed in the products, particularly as related to the heat treatment to which the milk was subjected during powder manufacture. Bitterness developed in many samples during storage. This was reflected by an increase in fluorescamine value. Age gelation of the product was not a major problem.

Whey products

J.F.Hardham
J.G.Zadow

In certain whey samples, the level of undenatured alpha-lactalbumin in UHT-processed whey increased substantially with decreasing pH, whereas in other samples, the reverse was the case. Further work is being undertaken to explain this variability.

Fibre fibrillation

G.Freischmidt[58]
J.F.Hardham
A.Michel[58]
J.G.Zadow

Preliminary studies were undertaken in collaboration with the CSIRO Division of Chemical and Wood Technology on the production of microfibrillated cellulose by homogenization of wood pulp. This product may have potential in the food industry as a bulking agent. It was necessary to modify the hydraulics of the homogenizer used in these studies to prevent fibre compacting in the valves.

Process chemistry

Dairy products

R.Grantham[12]
N.Hamer[12]
J.F.Hardham
H.R.Kocak
A.J.Miller[25]
J.G.Zadow

An ion-selective electrode was used for monitoring the short-term changes in ionic calcium content of heat-treated hydrochloric acid casein whey. After heat treatments ranging from 72°C for 15 s to 85°C for 30 min, the whey was cooled rapidly to 20°C, and the changes in ionic calcium monitored continuously for 120 min. The level of ionic calcium decreased after heating, but the percentage reduction immediately after heat treatment did not vary significantly as a function of the heat treatment employed.

Ultrafiltration (UF)

S.C.Marshall

The DRL Process Bay is equipped with a number of UF plants, and staff have developed considerable expertise in many aspects of membrane processing of both dairy and non-dairy products. Further assistance was given with aspects of membrane processing, including manufacture of a range of products, fractionation of whey proteins, and analysis of membranes using the dry ashing/atomic absorption method.

Reverse osmosis (RO)

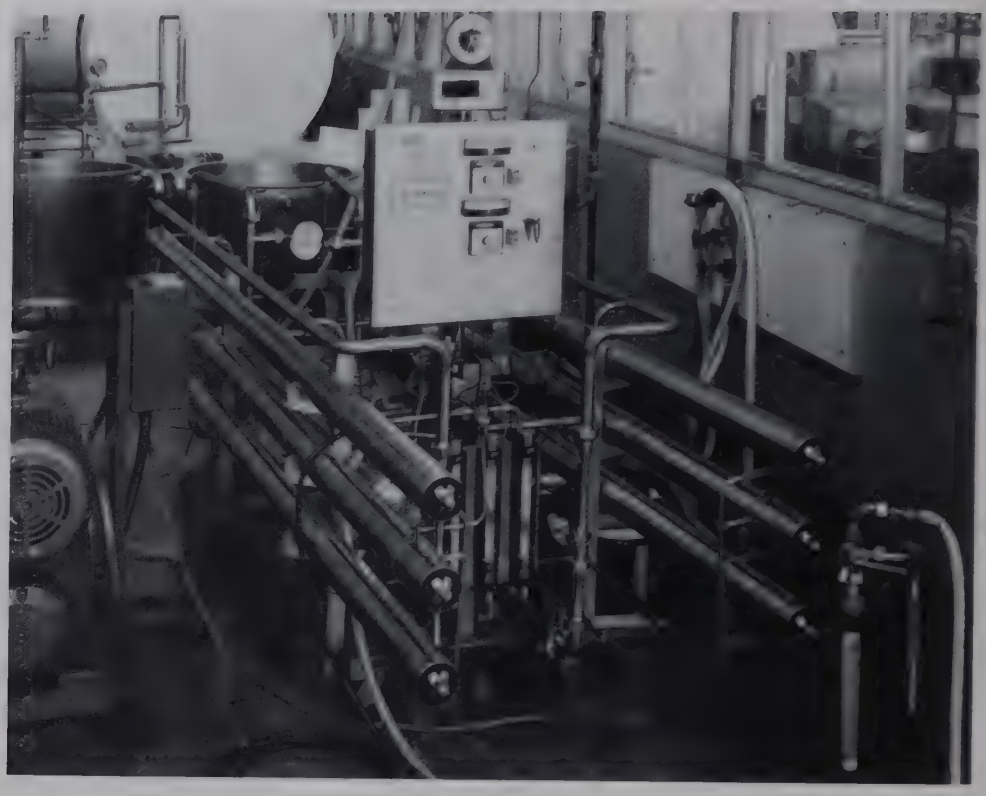
Concentration of milk

B.D.Dixon[51]
P.Drew[51]
J.A.Dunkerley
T.Jankowski
B.Kitchen[59]
H.R.Kocak
J.Manners[51]
S.C.Marshall
C.Versteeg[51]
T.Williams[51]

As reported previously, problems were encountered due to microbiological contamination of the concentrate produced using cellulose acetate (CA) spiral-wound membranes. Replacement of these with non-cellulosic (NON-CA) membranes overcame this problem. The NON-CA membranes also showed a higher retention of those substances not completely retained by CA membranes, such as mono-valent ions and low-molecular-weight polar organic compounds. However, these NON-CA membranes showed a rapid and irreversible loss in performance over very few hours of operation. They were therefore replaced with tubular NON-CA membranes. Satisfactory fluxes were obtained and microbiological quality of the concentrate was also satisfactory. Retention characteristics of the tubular membranes were similar to those of the earlier NON-CA membranes.

Batches of cheese were prepared at DRL and at the Gilbert Chandler Institute of Dairy Technology from rediluted 2:1 RO concentrate. Mass balance trials at DRL accounted for 99-100% of the total solids in the milk used. Cheese yields were not significantly different from the controls. Cheese made from diluted RO concentrate also appeared to have slightly lower moisture content than the control samples.

Initial studies were undertaken on the stability of RO concentrates to UHT processing. The concentrates were prepared at 2:1 concentration ratio, using the earlier NON-CA membranes. Samples of control milk, 2:1 RO concentrate (ROC) and rediluted RO concentrate (Recon ROC) were adjusted in pH from 6.5 to 6.8 at approximately 0.01 pH unit intervals, UHT processed, and the degree of sedimentation in the product assessed. Both ROC and Recon ROC appeared to have slightly improved stability below pH 6.6 compared to the control sample. The effect of RO concentration on the stability of UHT milk is also being examined in storage trials.



Reverse osmosis (RO) equipment

The RO plant was used to manufacture products such as REV (10% SNF, 1.5% fat) and SHAPE (12% SNF) from ROC, as well as for production of ROC for various demonstration purposes. In general, these samples were received favourably.

Following completion of current trials, it is expected that the capacity of the plant will be increased and it will be installed in a milk processing factory to allow a full-scale commercial evaluation of plant and products.

FLAVOUR CHEMISTRY

Determination of phenols and chlorophenols

I.Barlow
G.T.Lloyd
E.H.Ramshaw
H.Wrzesinski

An apparent increase in the number of phenol-related flavour defects in foods required improvements in analytical techniques. The steam distillation/h.p.l.c. method for the analysis of chlorophenols was developed into a routine method for determination of both phenols (phenol, methylphenol, ethylphenol) and chlorophenols (tri-, tetra-, penta-chlorophenol). A dual electrochemical detector operating at +0.90 V and +0.85 V allowed higher sensitivity than u.v. detection and provided selective response for the phenolic compounds.

A survey of component parts or composite samples of multiwall sacks was made in an attempt to associate chlorophenol in the packaging with chloroanisole in the product. Penta- and tetra-chlorophenol in the glued seams, trichlorophenol and tetrachlorophenol in the paper were associated with two occurrences of trichloroanisole and one occurrence of tetrachloroanisole in the product.

Biological formation of off-flavours

J.D.Daley

Samples of milk powder, a dry mixed cocoa-milk powder, cocoa mass, multiwall sacks and milk cartons were examined for the presence of fungi using a low water activity agar under various incubation conditions. Nineteen fungi were isolated, of which at least 11 grew in media containing chlorophenol. Five fungi (*Penicillium chrysogenum*, *Penicillium aurantiogriseum*, *Paecilomyces variotti*, *Aspergillus flavus* and *Cladosporum herbarum*) were selected for further study of their ability to grow in media with added tri-, tetra- and penta-chlorophenol and to dechlorinate tetra- and penta-chlorophenol. In similar studies the *Pseudomonas* spp. isolated from the same source as the fungi were capable of methylation and dechlorination.

Sixty-eight species of fungi were isolated in a survey of unused packages, factory air and laboratory air. Most of the fungi were found on one or more samples from the unused multiwall packaging sacks. Few organisms found in the air were present in the sacks. This raises the possibility that the sacks are contaminated early in their manufacture.

Objective assessment of milk quality

T.Milne[60]
G.E.Urbach

Preliminary work had suggested a relationship between the amount of ethanol in milk headspace and the time/temperature history of the milk. In a collaborative project with the Victorian Dairy Industry Authority, the headspace ethanol in pasteurized milk stored at 4°, 7° or 10°C increased after 15, 9, and 8 days respectively. Standard plate counts at the point of inflexion of the headspace ethanol/time curve were 5.1^6-2.1^7 c.f.u./ml.

The most prevalent bacterial colonies grown from aged, spoiled milk were *Pseudomonas fluorescens*. Three strains isolated from stored pasteurized milk each produced more ethanol at 30°C than at 4°C when grown in sterile milk. Two of the strains produced propen-2-ol at both temperatures. Addition of L-threonine to skim milk cultures of two of these strains increased cell production and ethanol production. However, addition of L-threonine to stored pasteurized milk did not increase the amount of ethanol produced.

Cheddar cheese flavour

I.Barlow
G.T.Lloyd
G.P.McCabe[61]
L.McCabe[61]
A.J.Miller[25]
E.H.Ramshaw

A bank of data comparing objective measurements (pH, lactic acid, soluble nitrogen, direct headspace sulphur compounds, direct headspace volatile compounds, extended headspace volatile compounds) and subjective assessments by a laboratory panel and by a Commonwealth grader describes the maturation of some 120 cheeses over three seasons of manufacture. Following a reappraisal of the statistical approach so as to allow for the variation in number of tasters in different trials, further statistical analysis was carried out. This showed good correlations between chemicals measured by direct headspace and by extended headspace analyses and also between soluble nitrogen and Cheddar flavour. Subsets of the measured chemicals were reasonable predictors of Cheddar flavour and some success in predicting Cheddar flavour at 12 months from measurements at an earlier age was achieved.

Cheese off–flavour

I.Barlow
E.A.Dunstone
G.T.Lloyd
E.H.Ramshaw
W.Stark

Commercial Cheddar cheese rejected for an off-flavour described as 'dirty, cowyard, sheepy' was examined by laboratory flavour panels and by instrumental analysis of volatile components. Isolation of a flavour extract followed by h.p.l.c. or g.c./m.s. identification implicated 4-methylphenol and 4-ethylphenol in the off-flavour. Previous occurrences of a similar-flavoured defect have been attributed to phenolic compounds, especially 4-methylphenol (*p*-cresol), formed as a result of contamination of the rennet with salt-resistant lactobacilli. Studies reported under Microbiology and Starter Research indicated a similar cause on this occasion.

Examination of a series of Cheddar cheeses by steam distillation in 'natural' or acidified conditions showed that the acid conditions released a considerable amount of bound 4-methylphenol and smaller amounts of bound phenol and 4-ethylphenol. The flavour quality and the flavour threshold concentrations of phenol, 4-methylphenol and 4-ethylphenol in cheese are being compared in 1:1 cheese:water slurries and Cheddar cheese made on the 10 kg scale with the phenolic compounds added to the milk or sprayed on the curd before pressing.

Mass spectrometry

W.Stark

Methods for the identification of chloroanisoles and chlorophenols, as acetates, in g.c./m.s. were refined by monitoring selected ions. Assessments were made by comparison of the selected ions with an external standard run under the same g.c./m.s. conditions and assuming 100% recovery in the isolation stages. As well as extensive use of the mass spectrometer as a selective detector, assistance was given to two companies, one for determination of chlorophenol acetates and one for headspace g.c./m.s.

Off–flavours

A significant effort was expended in investigating off-flavours in response to industry inquiries. In addition to the research on phenolic off-flavours in cheese and biological formation of off-flavours noted above, extensive investigations were made on:

- Phenolic off-flavours in sugar syrup
- Chlorophenolic off-flavours in reconstituted fruit juice and fruit drink
- Soapy off-flavours in ice cream caused, most probably, by lower fatty acids released by lipase action.

MATHEMATICS AND STATISTICS

Advice is given by mathematicians and statisticians located at the Division's main Laboratories on a variety of mathematical, statistical and computer techniques. Some recent projects are:

D.J.Best[25]
M.J.Buckley[25]

At FRL -

- Lipid biochemistry: Standard analysis of variance and canonical variates analysis were used to establish whether dietary crepenynic acid affected the fatty acid composition of the phospholipids of chickens.

- Rockmelon quality: Using taste test results and corresponding chemical measurements on rockmelons, an acceptance rule based on chemical measurements alone was sought. The best rule was to be the one which was correct most often when applied to the taste test data. Facilities for three-dimensional graphics were used to enable visual comparison of different acceptance rules based on the same two chemical measurements.

- Olfaction: Subjects were given flash cards with the names of common odours on them and asked to place the flash cards on a grid with what they considered similar odours closer together than dissimilar odours. Distances between each pair of odours were measured and then averaged of all subjects. From the average distances a 'distance matrix' was obtained and from the eigenvectors of this matrix an average odour 'map' was derived with like odours near like odours and less similar odours further apart.

P.N.Jones[25]

At MRL -

- Recent projects involved the design and analysis of taste testing investigations including Laboratory panels and consumer panels. The first type concerned testing the effect of turnip weed in the diet of pigs. A second experiment concerned the feeding of lupins in the diet of lambs. Consumer panels were used in an experiment to assess storage conditions in display shelves at a supermarket in Brisbane, and it is also proposed to use them to monitor preferences for various categories of beef.

G.McCabe[61]

At DRL -

The results of taste-testing experiments on the storage of Cheddar cheeses were analysed, in particular:

- Methods for adjusting the scoring for different tasters being present at different tasting sessions, and

- Investigation of relationships between taste scores and the chemical constituents of the cheese.

Affiliation of collaborating workers

[1]US Department of Agriculture, California, USA

[2]CSIRO Wheat Research Unit

[3]Macquarie University, Sydney, NSW

[4]CSIRO Division of Entomology

[5]Armed Forces Food Science Establishment, Scottsdale, Tasmania

[6]University of Sydney, NSW

[7]NSW Department of Agriculture

[8]Bread Research Institute of Australia, North Ryde, NSW

[9]University of California, San Diego, California, USA

[10]NSW Dairy Corporation

[11]Research Institute for Technology, Jakarta, Indonesia

[12]Royal Melbourne Institute of Technology Limited, Victoria

[13]University of New South Wales

[14]Michigan State University, East Lansing, Michigan, USA

[15]NSW Institute of Technology

[16]CSIRO Division of Human Nutrition

[17]Oregon State University, Corvallis, Oregon, USA

[18]Iowa State University, Ames, Iowa, USA

[19]CSIRO Division of Tropical Animal Science

[20]Middlesex Hospital Medical School, London, UK

[21]University of British Columbia, Vancouver, BC, Canada

[22]State University of New York, Buffalo, NY, USA

[23]University of Queensland

[24]North-Eastern Ohio Universities College of Medicine and Kent State University, Ohio, USA

[25]CSIRO Division of Mathematics and Statistics

[26]Queensland Department of Primary Industries

[27]South China Institute of Botany, Academia Sinica, Guangzhou, People's Republic of China

[28]Malaysian Agricultural Research and Development Institute, Serdang, Malaysia

[29]University of Malaya, Kuala Lumpur, Malaysia

[30]Department of Primary Industries, Papua New Guinea

[31]ARCO Plant Cell Research Institute, Dublin, California, USA

[32]University of Montreal, PQ, Canada

[33]Kagoshima University, Kagoshima, Japan

[34]Hokkaido National Agricultural Experiment Station, Sapporo, Japan

[35]University of Wollongong, NSW

[36]Loma Linda University and Veterans Administration Hospital, California, USA

[37]Agricultural Research Organization, The Volcani Center, Bet Dagan, Israel

[38]Hebrew University of Jerusalem, Rehovot, Israel

[39]University of California, Davis, California, USA

[40]Branch and Associates Pty Ltd

[41]Australian Maritime College, Launceston, Tasmania

[42]University of Tasmania

[43]Research Institute for Fish Technology, Jakarta, Indonesia

[44]Griffith University, Nathan, Queensland

[45]Australian Atomic Energy Commission, Lucas Heights, NSW

[46]CSIRO Energy Management Unit

[47]University of Nottingham, UK

[48]Livestock and Meat Authority of Queensland

[49]Northern Territory Department of Primary Production

[50]Australian Dairy Culture Association

[51]Gilbert Chandler Institute of Dairy Technology, Werribee, Victoria

[52]University of Melbourne, Victoria

[53]National Institute for Allergy and Infectious Diseases, Frederick, Maryland, USA

[54]Darling Downs Institute of Advanced Education, Toowoomba, Queensland

[55]Australian Dairy Corporation

[56]Consultant

[57]Australian National University, Canberra, ACT

[58]CSIRO Division of Chemical and Wood Technology

[59]Cadbury Schweppes Pty Ltd

[60]Victorian Dairy Industry Authority

[61]Purdue University, Lafayette, Indiana, USA

COMMITTEES

Members of the Division serve on a variety of committees, on some in an official capacity as officers of CSIRO, and on others because of their professional interests and expertise.

The following list makes no attempt at completeness, but is indicative of the wide representation provided by members of staff in the general field of food research.

Academic Press - Monograph Series - Editorial Board
Advances in Food Analysis - Editorial Board
Advances in Food Research - Editorial Board
American Society for Testing Materials - Committee E18
  Sensory Evaluation
Appetite - Journal for Intake Research - Editorial Advisory
  Board
Australian Academy of Science -
  National Committee for Nutritional Sciences
  National Committee for Plant Sciences
Australian Apple and Pear Corporation - Processing Committee
Australian Chicken Meat Research Committee and its Research
  Advisory Panel
Australian Codex Panels on -
  Fats and Oils
  Fish and Fishery Products
  Food Additives
  Food Contaminants (Metals)
  Food Hygiene
  Food Labelling
  Processed Fruit and Vegetables
  Processed Meat and Poultry Products
  Quick Frozen Foods
Australian Consumers Association - Consumer Education and
  Product Testing
Australian Dairy Products Standards Organization -
  Working Party
  Microbiology Sub-Committee
  Working Group on Microbiological Standards for Cheese
  Working Group to Develop Standards for Milk at the Retail
    Level
Australian Defence Forces Food Specification Committee
Australian Development Assistance Bureau - Committee: The
  Tuvalu Fisheries Development Program
Australian Institute of Food Science and Technology -
  Council, Branch and Group Committees
  Working Party on Food Inspection
Australian Maritime College Commonwealth Accreditation Com-
  mittee for Advanced Education - BAppSc - Fisheries Tech-
  nology Panel
Australian Institute of Physics - Science Policy Committee
Australian Meat Research Committee -
  Meat Research Advisory Panel
  Industry Section Liaison Sub-Committee
Australian Nutrition Foundation - Council, and NSW Division
Australian Society for Biophysics
Australian Society of Dairy Technology -
  Federal Executive
  Finance Committee
  Publications Committee

Australian Society for Microbiology Inc. - National and Branch Committee
Bread Research Institute of Australia - Council
British Food Manufacturing Industries Research Association Taints and Off-Flavours Working Committee
Chemical Senses - Editorial Board
Consumer Education Freezing of Foods Council (NSW)
Council of Australian Food Technology Associations -
- Food Legislation Committee
- Education Sub-Committee
- Journal Management Committee

Department of Industry, Technology and Commerce -
- Processed Food Industry Council

Department of Primary Industry -
- Australian Bureau of Animal Health: Subcommittee on Veterinary Public Health
- Australian Dairy Research Committee
- Dried Fruits Research Committee
- Fishing Industry Research Committee
- Meat Industry Advisory Committee -
  - Meat Product Code Committee
  - Technical Sub-Committee on Edible Protein Residue
- DPI-NMPA-CSIRO-AMLC Committee on Meat Processing Regulations

Department of Science - National Research Fellowships Advisory Committee
European Chemo-Reception Research Organization - Editorial Board
Food Reviews International - Advisory Board
Food Technology Association (Tasmanian Branch)
Gilbert Chandler Campus of Horticulture and Agriculture - Advisory Committee
Gilbert Chandler Institute of Dairy Technology - Advisory Committee
Gosford Horticultural Postharvest Laboratory - Research Advisory Committee
Griffith University Research Grants Committee
Hawkesbury Agricultural College of Advanced Education -
- Council, and its Education Committee
- School of Food Sciences Advisory Board
- Course Assessment Committee (NSW Higher Education Board)
- School of Horticulture Advisory Committee on BAppSc Horticulture

Herbivore Nutrition - 2nd International Symposium (1987) - Organizing and Program Committee
Horticulture Congress Trust
Indo-Pacific Fishery Commission Working Party on Fish Technology and Marketing
Industrial R & D Incentives Act, 1976 -
- Section 39 Steering Committee
- Plate Freezing of Meat

Institution of Chemical Engineers -
- Queensland Branch: Executive Committee

International Association of Microbiological Societies -
- International Committee on Food Microbiology and Food Hygiene

International Association for Plant Physiology - Executive Committee
International Association on Water Pollution Research and Control - Study Group on Tastes and Odours

International Commission on Microbiological Specifications for Foods
International Commission on Mycotoxicology
International Commission on Taxonomy of Fungi
International Conference on Biochemistry of Lipids - Steering Committee
International Dairy Federation and its Specialist Groups
Australian National Committee
International Frozen Food Association - Scientific and Technical Advisory Group
International Institute of Refrigeration -
Australian National Committee
Commission C1 Freeze Drying
Commission C2 Food Science and Technology
Commission D2 Refrigerated Land Transport
Thermophysical Properties of Foodstuffs Working Party Committee
International Journal of Food Microbiology - Editorial Board
International Life Science Institute -
Board of Trustees (Australia)
Executive Secretary (Australia)
International Organization for Standardization - Working Group ISO/TC 34/SC 6WG15 - Meat and Meat Products - Enumeration of Lactic Acid Bacteria
International Union of Food Science and Technology, and its Working Group on Influence of Smoking and Drying on Nutritional and Functional Properties of Fish
International Union of Pure and Applied Chemistry - Commission on Fats and Oils
ISOPOW/IUFoST Executive Committee, and its Publications and Finance Sub-Committees
Journal of Chromatography (Biomedical Applications) - Editorial Board
Journal of Texture Studies - Editorial Board
Macquarie University -
Schools Committee, School of Biological Sciences
Biosafety Committee
Meat and Allied Trades Advisory Committee on Technical Education
Meat Industry Advisory Committee -
Specialist Committee on Design Building Construction Materials and Equipment for Use in Meat Industry
Working Party on Loading of Shipping Containers
Meat Science - Editorial Board
Melbourne and Metropolitan Board of Works Consultative Panel for Odour Reduction
National Association of Testing Authorities (Assessors)
National Health and Medical Research Council -
Food Standards (Standing) Committee
(Reference) Sub-Committees on Food Microbiology, and Food Science and Technology
Working Parties on -
Food Composition Data
Fruit Juice Standards
Liquid Milk and Milk Products
Mechanically Separated Meat
Processing Aids
Standards for Cheese
Standards for Special Dietary Foods
National Peanut Council of Australia - Technical Committee

NSW Department of Technical and Further Education -
  Food Technology Advisory Committee
  Food Technology Certificate Course Advisory Committee
NSW Institute of Technology -
  Biological and Biomedical Sciences Course Advisory Committee of School of Life Sciences
  Committee of Review, MSc Program
Nuclear Magnetic Resonance National Conference for 1985
Nutrition Society of Australia - Sydney and Brisbane Groups
Poultry Research Advisory Committee
Queensland Board of Advanced Education - Applied Science Field of Study Review Committee
Queensland Institute of Technology -
  Council
  Academic Assembly
  Applied Physics Course Advisory Committee
  Research & Development Support Committee
Queensland Working Group - Study of Post Farm Treatment of Pigs in Queensland
Royal Australian Chemical Institute -
  Polymer Group
  Colloid and Surface Chemistry Committee
Royal Melbourne Institute of Technology - Department of Applied Chemistry, Course Advisory Committee on Food Science and Technology
South-East Queensland Goat Club
Standards Association of Australia - Committees and Sub-Committees dealing with:
    Dairying Standards Board
    Methods for Sampling of Milk and Dairy Products
    Methods for Chemical Analysis of Dairy Products
    Microbiological Methods for Examination of Dairy Products and for Dairy Purposes
    Cleaning and Sanitation in the Meat, Poultry, Seafood Industries
    Egg and Egg Products
    Frozen Food Retail Cabinets
    ISO Standards for Foods
    Microbiological Examination of Food
    Plastics for Food Contact
    Sensory Evaluation of Foods
    Double Seams for Metal Cans
    Polyethylene Film
Standing Committee on Agriculture -
  Advisory Group on Application of Irradiation Technology to Foodstuffs
  Entomology Committee - Container Disinfestation Working Party
  Horticultural Postharvest Research Committee
  Technical Sub-Committee - Poultry Production
Tasmanian Health Department - Food Standards Committee
Thermal Biology Journal - Editorial Board
University of New South Wales - Visiting Committee for School of Food Technology
University of Tasmania - Faculty of Agricultural Sciences

PUBLICATIONS

*Indicates that author is not a member of the Division.

†Indicates that author is not a member of the Division but is stationed permanently at a Divisional Laboratory.

§Indicates that author is an officer of the New South Wales Department of Agriculture.

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Serials

CSIRO FOOD RESEARCH QUARTERLY. North Ryde, NSW. V.44, nos.1,2, 3,4 (1984); V.45, nos.1,2 (1985).

MEAT RESEARCH NEWSLETTER. Cannon Hill, Qld.
No.84/3 The storage life of chilled vacuum packaged pork.
No.84/4 Curing of hides and skins.
No.84/5 Recommendations for the cooling of hot-boned meat.
No.85/1 Liveweight and carcass weight loss in cattle.
No.85/2 Interpretation of bacteriological tests on vacuum packaged meat.
No.85/3 Short-term preservation of hides and skins.
No.85/4 Ham production - Part I: General cooking and processing factors.

PATENTS

Patents are listed below in chronological order, with the year of the Australian applications in brackets:

CZULAK, J. (1967). Draining and processing of curd in the manufacture of cheese. U.S. Pat. 3 523 367, Canadian Pat. 873 809.

CZULAK, J., FREEMAN, N.H., and O'CONNELL, J.R. (1969). Flow bucket for cheese making. U.S. Pat. 3 695 893, Canadian Pat. 897 088.

CZULAK, J., and SUTHERLAND, B.J. (1971). Semi-continuous cheese-making process machine. Canadian Pat. 979 274.

PARK, R.J., and LEPPIK, R.A. (1980). Fermentation of bile. Australian Pat. 531 753, Canadian Pat. 1 167 030, New Zealand Pat. 196 277.

CASIMIR, D.J. (1980). Reversing diffusion extractor. British Pat. 2 079 176, U.S. Pat. 4 363 264.

PEARCE, R.J. (1982). Extraction of protein from sunflower meal. U.S. Pat. 4 435 319.

New Patents pending:

HOLLAND, R.V., ROONEY, M.L., and BOARD, P.W. (1980). Measuring oxygen permeabilities of polymer films. Australia.

JAMESON, G.W., and SUTHERLAND, B.J. (1980). Liquid pre-cheese product. Australia and USA.

PARK, R.J., and LEPPIK, R.A. (1980). Fermentation of bile. Europe and USA.

KOCAK, H.R., and ZADOW, J.G. (1981). UHT milk. Australia.

BARLOW, I.E., HARDHAM, J.F., and ZADOW, J.G. (1981). UHT process. Australia.

DAVEY, K.R. (1982). Fat hardness measurer. Australia.

LEEUWEN, H.J.van, FREEMAN, N.H., SUTHERLAND, B.J., and JAMESON, G.W. (1982). Hard cheese from UF concentrate. Australia, Canada, New Zealand and Eire.

FREEMAN, N.H., JAMESON, G.W., LEEUWEN, H.J.van, and SUTHERLAND, B.J. (1983). Continuous coagulator. Australia.

BOYCE, P.R., CHASTEL, D.de, KERR, D.T., RANKIN, R.J., TRITCHLER, R.W., and WESCOMBE, G.L.J. (1983). Automatic slaughter system. Australia.

PARK, R.J., DUNN, N.W.*, and IDE, J.A.* (1983). Process for the preparation of hydroxy-1 4-androstadriene-3 17 dione compounds. Australia, Netherlands, USA and Japan.

ZADOW, J.G., MITCHELL, I.R., and HAYES, J.F. (1985). Lactose hydrolysis. Australia.

MELLOR, J.D., and BELL, G.A. (1985). Isothermal adsorption freeze-drying process. Australia.

*Co-inventor is not a member of Division.

INDUSTRY AND CONSUMER LIAISON

Food Research Laboratory (FRL)

Liaison and Extension Group	
Leader (Industry Liaison Officer)	K.C.Richardson,BSc
Industry Liaison Officer	P.J.Rutledge,AAIFST
Consumer Liaison Officer	G.Fisher,MScSoc
Editor	G.J.Walker,MSc
At Tasmanian Food Research Unit, Hobart (TFRU)	
Extension and Liaison Officer	S.J.Thrower,MSc,DipEd

Meat Research Laboratory (MRL)

Industry Section	
Leader	V.H.Powell,MSc,PhD
Information Officer	B.Y.Johnson,BAgrSc
Extension Officer (Perth)	P.M.Husband,BAppSci
" " (Melbourne)	D.R.Smith,ARMIT
" " (Sydney)	W.F.Spooncer,BSc

Dairy Research Laboratory (DRL)

Information Officer	Miss H.P.Dornom,BAgrSc

STAFF AT 30 JUNE 1985

Headquarters of Division

In Food Research Laboratory, North Ryde, NSW

Chief of Division	J.H.B.Christian,BScAgr,PhD,FAIFST,FTS
Divisional Secretary	I.R.McDonald,BCom
Personal Secretary	E.M.Henderson

Food Research Laboratory (FRL)

North Ryde, NSW

Officer-in-Charge and Assistant Chief	A.R.Johnson,BSc,PhD,FAIFST
Administrative Officer	R.D.Lipscomb,BSc
Engineer	I.A.Stafford,BE,ASTC
Senior Technical Officer (Assistant to Engineer)	G.B.Morgan
Senior Technical Officer (Photographer)	W.E.Rushton
Librarian	I.A.Mathieson,BSc,BE,GradDipLibSc
Library Officers	J.M.Lawson J.H.Maddalena

Liaison and Extension

Scientific Services Officers	K.C.Richardson,BSc (Leader) G.Fisher,MScSoc P.J.Rutledge,AAIFST G.J.Walker,MSc

Applied Food Science

Chief Research Scientist	A.R.Johnson,BSc,PhD,FAIFST (Research Leader)
Senior Principal Research Scientist	P.W.Board,BSc,FAIFST
Principal Research Scientists	D.J.Casimir,MSc,DipEd,PhD,FAIFST R.V.Holland,MSc,PhD A.G.Lane,MSc,PhD A.K.Sharp,BE,MEngSci,PhD
Senior Research Scientists	M.L.Rooney,MSc R.J.Steele,BSc,PhD,MBA
Senior Experimental Scientist	A.R.Irving,BSc
Experimental Scientists	D.Barnett,BSc N.Chau-Ngoc,BE,MEng* P.G.Gwatkin,BSc (located at Mildura, Vic.) R.P.Kozyrod,BSc,PhD*
Senior Technical Officers	B.R.Crowley,BA W.C.Osborne R.A.Santangelo D.Watson
Technical Officer	D.B.Drewitt-Smith
Technical Assistants	L.Catoe*# R.J.Coghlan L.Lindsey
Senior Laboratory Craftsman	D.J.Noice

Chemical Bases of Food Acceptance

Senior Principal Research Scientists	B.V.Chandler,BSc,PhD,MSc(Biotech),FAIFST (Research Leader)
	F.B.Whitfield,MSc,ASTC,PhD
Principal Research Scientist	D.G.Laing,BSc,PhD
Senior Research Scientists	G.A.Bell,MA,PhD
	R.L.Johnson,MSc,DipEd,PhD
	R.L.McBride,BSc,PhD
Senior Experimental Scientist	G.Stanley,BSc,ASTC
Experimental Scientists	V.J.Gupta,MSc,PhD*#
	J.H.Last,ASTC
	T.H.L.Nguyen,BSc
	H.H.N.Panhuber,BA,MSc
	K.J.Shaw,BA
	C.R.Tindale,BApSc
Senior Technical Officers	E.J.Bourn
	D.Gallimore
Technical Officer	J.M.Myers*
Technical Assistants	R.E.Gibson*
	S.D.Levingston,BApSc*
	M.J.Vickery (part-time)*

Food Safety and Nutritional Quality

Principal Research Scientists	A.C.Fogerty,MSc (Research Leader)
	R.F.Adams,AAIFST
	R.L.Hood,BSc,PhD
	J.I.Pitt,MSc,ASTC,PhD
	G.S.Sidhu,BScAgr,PhD (overseas)
	A.D.Warth,MSc,PhD
Senior Research Scientist	A.J.Evans,MSc,PhD
Research Scientist	J.A.Lindsay,BSc,PhD
Experimental Scientists	P.S.Casey,BScAgr,PhD (part-time)
	M.J.Eyles,BSc,PhD
	G.L.Ford,BA,MSc
	A.D.Hocking,BSc
	A.M.Irwin,BSc*
	N.F.B.Tobin,BSc
	K.A.Wheeler,BSc
Senior Technical Officers	S.Kozuharov
	D.Svoronos
Technical Officer	H.Podhaiski
Technical Assistants	C.R.Beales
	P.L.Clements
	R.S.Kelly,BEd*#
	L.C.Tuffs (part-time)

Food Structure

Senior Principal Research Scientists	J.Middlehurst,MSc (Research Leader)
	R.W.Burley,MSc,PhD
Principal Research Scientists	B.A.Cornell,BSc,PhD
	L.R.Fisher,MSc,PhD
	D.G.Oakenfull,MSc,PhD
	N.S.Parker,BSc,PhD
Senior Experimental Scientist	B.H.Kennett,ASTC
Experimental Scientists	J.F.Back,BSc,DipEd
	G.W.Francis,MSc

	F.E.Separovic,BA
	F.S.Shenstone,ASTC
	R.W.Sleigh,MSc,PhD (overseas)
Senior Technical Officers	R.A.Gamble
	A.G.Scott
Technical Assistants	F.Azimi*#
	S.Kamdar*#
	E.Mitchell
	B.Vartouhi*
	R.D.Voullaire*#
	L.E.Weir

Plant Physiology

(†Located at Macquarie University)
(θLocated at Gosford Horticultural Postharvest Laboratory)

Chief Research Scientists	J.K.Raison,BSc,PhD†
	R.M.Smillie,MSc,PhD,DSc
Senior Principal Research Scientists	D.Graham,BSc,PhD (Research Leader)
	D.G.Bishop,MSc,PhD†
	W.B.McGlasson,BAgSc,PhD
Principal Research Scientists	C.J.Brady,MScAgr,PhD†
	B.D.Patterson,BSc,PhD
Senior Research Scientist	J.Speirs,MSc,PhD†
Senior Experimental Scientist	J.E.Algie,BE,ASTC,MSc,DU(Toulouse)
Experimental Scientists	M.A.Brown,MSc,DipTech(Sci),PhD†
	G.R.Chaplin,BScAgr,MSc,PhD
	S.P.Cole,BSc
	D.G.Hockley,BSc
	E.E.Kavanagh,BSc
	P.B.H.O'Connell,MSc†
	J.A.Pearson,MSc†
	S.H.Satyan,MSc,PhD
	A.J.Shorter,BSc
Senior Technical Officers	J.R.Kenrick,AAIMLS†
	S.K.Meldrum,BApSc
	R.S.Nott
	L.A.Payne
	P.Watt,BSc
Technical Officers	E.Lee,BA†
	W.J.New
	G.R.Orr,BSc†
	S.A.Spraggon (part-time)
Technical Assistants	A.I.Eddy
	M.R.Forbes-Smith,BAgScθ
	D.W.Mayne*
	T-L.Morris*§θ
Senior Laboratory Craftsman	M.Schenk

Tasmanian Food Research Unit (at Hobart, Tas.)

Senior Principal Research Scientist	J.Olley,PhD,DSc,FAIFST,FIFST,FTS (Research Leader)
Senior Experimental Scientist	H.A.Bremner,MSc,ARMIT
Experimental Scientists	A.R.Quarmby,AAIFST
	J.A.Statham,BAgrSc
	S.J.Thrower,MSc,DipEd
Technical Officers	L.B.Barker
	P.S.Kearney
	A.M.A.Vail
Technical Assistant	M.L.Ottenschlaeger

Workshops

Senior Technical Officer	A.G.R.Clark (Workshop Supervisor)
Senior Laboratory Craftsmen	R.J.Allen (Leading Hand)
	G.Calvi (Leading Hand)
	N.A.Leyer
	K.A.Luff
	G.D.Truelove
Laboratory Craftsman	A.J.Restuccia*
Apprentices	P.Britt
	G.F.Hodson
Handyman	R.Gallo

Administration

Administrative Officers	P.A.Constable,BEc*
	M.T.Turner,BA
Clerk	A.J.McGuinness,BA*
Clerical Assistants	G.Carter
	M.Coyle
	M.T.Dominello*
	J.A.Haven
	M.T.Lock*§
	G.A.Moore
	R.Searle*§
	J.Willcox
Steno-Secretary	M.E.Wigney (part-time)
Word Processing Typists	B.E.Chambers
	R.L.Ferrarin
	D.J.Williams (Supervisor)
Senior Storekeeper	J.G.Lawson*
Handyman	B.J.Rayner
Caretaker	H.Hayes

Meat Research Laboratory (MRL) (Cannon Hill, Qld)

Officer-in-Charge and Assistant Chief	D.J.Walker,BSc,PhD,DSc,FAIFST
Administrative Officer	M.J.Lilley

Scientific Services

Librarian	E.E.Dickason,BSc,DipEd,DipLib
Library Officer	J.E.Gould,ALAA

Muscle Biology and Meat Science

Meat Science

Senior Principal Research Scientists	J.J.Macfarlane,MSc,FRACI,FAIFST (Section Leader)
	P.V.Harris,BSc,PhD (Group Leader)
Principal Research Scientists	N.L.King,MSc,PhD
	V.H.Powell,MSc,PhD,FRACI
	W.R.Shorthose,BSc,PhD
Experimental Scientists	R.G.Hamilton,BAppSci
	L.B.Kurth,BAppSci,MPhil
	I.J.McKenzie,MAppSci
	F.D.Shaw,BSc,MVSc
Senior Technical Officer	R.F.Dickinson

Technical Officers	S.L.Beilken
	R.A.Gibbons
	I.Griffiths
	F.J.van Doore,BAppSci
Technical Assistant	D.P.Sharp*
Muscle Biology	
Principal Research Scientists	R.W.Rowe,BSc,PhD (Group Leader)
	D.J.Morton,BSc,PhD
	R.F.Thornton,BSc,PhD
	R.K.Tume,BSc,PhD
Senior Research Scientist	D.J.Horgan,BSc,BEcon,PhD
Experimental Scientist	J.F.Weidemann,BSc
Senior Technical Officers	G.W.Johnson
	T.W.Larsen,BAppSci
Technical Officers	S.Dyson
	R.Kuypers
Microbiology and Meat Technology	
Microbiology and Biotechnology	
Senior Principal Research Scientist	F.H.Grau,MSc,PhD (Section/Group Leader)
Principal Research Scientists	R.J.Park,MSc,PhD,FRACI (Group Leader)
	A.F.Egan,MSc,PhD
Senior Research Scientist	R.A.Leppik,MSc,PhD
Senior Experimental Scientists	I.J.Eustace,BAgSci
	M.G.Smith,BSc
Postgraduate Student	D.E.Miller,BSc*
Senior Technical Officers	B.W.Arantz
	B.A.Bill
	B.J.Shay
Technical Officers	G.M.Higgs,BAppSci
	J.E.McDonald
Technical Assistants	D.J.Devine,BAppSci
	P.B.Vanderlinde
Engineering Studies	
Principal Research Scientist	L.S.Herbert,BSc
Research Scientist	K.R.Davey,BChemEng,MEngSc,PhD (Group Leader)
Senior Experimental Scientists	D.T.Kerr,DipMechEng
	D.A.Lovett,BSc
Experimental Scientists	H.M.Chua,BEng,MBA
	R.J.Rankin,BEng(Mech)
Senior Technical Officers	N.G.McPhail
	R.W.Tritchler
	G.L.Wescombe
Technical Officers	B.L.Baudistel*
	B.P.Cain
	D.J.de Chastel
	R.M.White
Senior Laboratory Craftsman	P.R.Boyce
Extension	
Scientific Services Officers	B.Y.Johnson,BAgSci
	P.M.Husband,BAppSci (Perth, WA)
	D.R.Smith,ARMIT (Melbourne, Vic.)
	W.F.Spooncer,BSc (Sydney, NSW)
Steno-Secretaries	M.A.Jarrett
	E.Schwanitz (Melbourne, Vic.)*
	P.Vinton (Perth, WA)*

Clerical Assistants	A.M.Krafft
	J.A.Page (Sydney, NSW)
Workshop, Animal Yards, etc.	
Senior Technical Officers	V.D.Townsend (Supervisor)
	R.R.Weste
Technical Officer	R.J.Logue
Senior Laboratory Craftsmen	D.E.Bailey
	J.W.Prosser
	B.L.Rumley
Laboratory Craftsman	P.P.Jard
Apprentices	V.K.Cairns¶
	P.A.Tracy
Administration and General	
Administrative Officer	A.T.Scott
Clerk	J.S.Burrows
Clerical Assistants	J.Francais
	M.R.Howard
	A.G.Keen
	B.J.Penman
	M.J.Wright*
Technical Assistant	J.W.Ward
Assistant (Food Services)	M.A.Colonna
Assistant (Transport)	S.G.Clair

Dairy Research Laboratory (DRL) — Highett, Vic.

Officer-in-Charge and Assistant Chief	L.L.Muller,BSc,FIDM,FAIFST,FTS
Administrative Officer	G.S.Barnes*
Scientific Services	
Scientific Services Officer (Industry Liaison)	H.P.Dornom,BAgrSc
Librarian	S.M.Collins,ALAA,DipComm,Data Proc.
Library Officer	D.J.Kelson,BSocSci(Lib),ALAA
Cheese Technology	
Principal Research Scientist	G.W.Jameson,BSc,PhD (Research Leader)
Senior Research Scientist	B.J.Sutherland,ARACI
Experimental Scientists	G.C.Dixon,BSc*
	D.T.Taylor,BSc
	K.Nguyen Thi,BSc
Senior Technical Officers	G.Pettingill
	R.J.Prince
	R.M.Shanley,ARMIT
Technical Officer	T.Mounsey
Technical Assistants	P.J.Hull
	L.J.Johnson*
Assistant (Laboratory Services)	D.M.Williamson (part-time)*

Starter Research

(†Located at Russell Grimwade School of Biochemistry, University of Melbourne)

Senior Research Scientists	R.R.Hull,BSc,PhD (Research Leader)(overseas)
	A.J.Hillier,BSc,PhD.†
Experimental Scientists	D.W.Eddy,BSc
	A.Orsini,BSc
Technical Officer	A.Roberts (part-time)
Technical Assistants	D.Greaves,BSc*§
	S.Toyne
Assistant (Laboratory Services)	H.J.Brown†

Milk Components

Principal Research Scientists	F.G.Kieseker,BAgrSc (Research Leader)
	R.J.Pearce,BSc,PhD
Experimental Scientist	S.M.Claughton,BAppSc
Senior Technical Officers	B.Aitken
	P.T.Clarke
	P.D.Shimmin
Technical Assistants	N.Boyarsky,BSc*§
	W.Cougle*

Unit Processes

Principal Research Scientist	J.G.Zadow,MSc,DAppSc (Research Leader)
Senior Experimental Scientist	J.F.Hayes,BSc
Experimental Scientists	J.A.Dunkerley,DipAppChem
	J.F.Hardham,AAIFST
	H.R.Kocak,BAppSc,MSc
	S.C.Marshall,DipAppChem,DipChemEng(grad)
	I.R.Mitchell,BSc
Technical Assistants	M.J.Free,BSc
	A.C.Mohyla,BSc*

Flavour Chemistry

Senior Research Scientists	E.H.Ramshaw,MA,PhD (Research Leader)
	G.T.Lloyd,BSc,PhD
	G.E.Urbach,MSc
Senior Experimental Scientist	W.Stark,ARACI
Experimental Scientist	J.Daley,BSc
Senior Technical Officers	I.E.Barlow
	E.A.Dunstone

Engineering Workshop

Senior Experimental Scientist	N.H.Freeman (Leader)
Experimental Scientist	B.J.Trerice,BEng(Mech),MEngSc
Senior Technical Officer	W.P.King
Technical Officer	P.D.Smith
Senior Laboratory Craftsmen	B.W.Beere (Foreman)
	J.Fagan
	E.A.Green
	R.J.Lloyd
	A.P.Lund
	T.L.Mackey
Laboratory Craftsman	D.J.Carruthers
Apprentice	P.Stephenson
Handyman	N.C.Day*§

Process Bay

Senior Technical Officer	J.J.Mayes
Technical Assistant	V.J.Mackie
Assistant (Laboratory Services)	G.W.Robinson

Administration and General

Clerk	J.J.Barnes*
Clerical Assistants	J.Horwood
	B.C.Jones
	C.J.Williamson*
Steno-Secretary	J.E.Dudley
Typist	K.E.Egan

The following are stationed at North Ryde, NSW:

Honorary Research Fellows	J.F.Kefford,MSc,FAIFST
	J.D.Mellor,MAIP
	K.E.Murray,DSc,FRACI,FAIFST,FTS
	J.R.Vickery,OBE,MSc,PhD,FRACI,FAIFST,FIFST,FTS
Post-Retirement Research Fellow	M.B.Smith,DSc,ASASM

From CSIRO Division of Mathematics and Statistics

Experimental Scientists	D.J.Best,MSc,DipMet
	M.E.Willcox,BSc

From CSIRO Headquarters

Staff Counsellor	A.R.F.Choy,BA,MEd

From NSW Department of Agriculture (Attached to Plant Physiology Group)

Senior Research Scientists	K.J.Scott,BScAgr,DipEd
	N.L.Wade,BScAgr,PhD
Principal Horticulturist (Postharvest)	B.B.Beattie,MScAgr (part-time)

The following are stationed at the Gosford Horticultural Postharvest Laboratory, NSW (operated jointly by CSIRO and NSW Department of Agriculture):

From NSW Department of Agriculture

Senior Research Horticulturists	B.L.Wild,BScAgr,MSc,PhD (Officer-in-Charge)
	C.J.Rigney,BScAgr,MSc,PhD
Research Horticulturist	S.C.Morris,BScAgr,PhD
Assistants	R.J.Smith
	K.R.Ward
	S.M.West
Typist	L.Booth

The following are stationed at Cannon Hill, Qld:

From CSIRO Division of Mathematics and Statistics

Experimental Scientist	P.N.Jones,MSc (part-time located at CSIRO Division of Tropical Crops and Pastures, St.Lucia, Qld)

From CSIRO Energy Management Unit

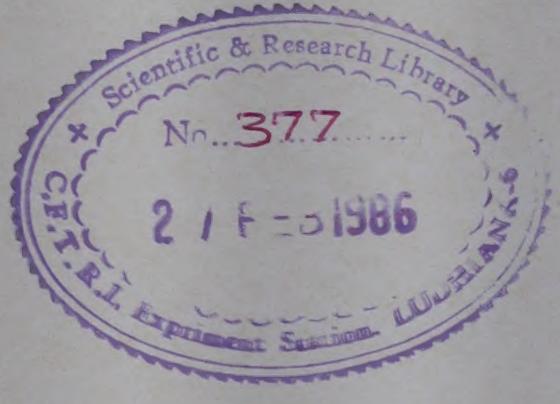
Experimental Scientist	J.W.Buhot,BEng(Mech) (Manager)
Senior Technical Officers	J.Anderson
	W.K.Larnach

From Meat and Livestock Authority, Queensland

Technician	L.Eadie

The following are stationed at Highett, Vic.:

From Australian Dairy Corporation Technical Services Group	D.Radford
From Australian Dairy Culture Association	M.R.Graham



*New appointment

§Government Special Youth Employment and Training Program (SYETP)

¶National Employment Strategy for Aboriginals Scheme

#Community Employment Program (CEP)